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ERRATA.

Page 75, line 26, for " *M. fractinervis* " read " *R. fractinervis* "
,, 115, line 18, page 119, line 30 and page 134, line 18, for " *B. van der Goot* " read " *P. van der Goot* "
,, 135, line 23 and page 144, 14 lines from end, for " *medianalis* " read " *medinalis* "
,, 372, line 16, for " *zeylandica* " read " *zealandica* "
,, 373, 3rd line of legend for Fig. 4, for " *Newsteadi* " read " *Newsteadia* "
,, 377, line 2, for " *Hedycarpa* " read " *Hedycarya* "

IMPERIAL BUREAU OF ENTOMOLOGY.

BULLETIN

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OBSERVATIONS UPON *LIXOPHAGA DIATRAEAE*, TOWNSEND, A TACHINID PARASITE OF *DIATRAEA SACCHARALIS*, FABR., IN PORTO RICO.

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The Tachinid fly parasite of *Diatraea saccharalis*, F. (sugar-cane moth borer), which forms the subject of the present paper, was described in 1916 by Dr. C. H. T. Townsend[1] under the name *Euzenilliopsis diatraeae*. In 1924, Dr. J. M. Aldrich[6] pointed out that Dr. Townsend's new genus was untenable and referred *E. diatraeae* to *Lixophaga*, Towns., of which *Euzenilliopsis*, Towns., is now considered a synonym. In certain of the earlier papers in which this fly is mentioned as a parasite of *D. saccharalis*, it is referred to as *Tachinophyto* (*Hypostena*) sp.

Lixophaga diatraeae seems to be limited in its natural distribution to certain of the Greater Antilles, records of its occurrence coming from Cuba, Santo Domingo, and Porto Rico, and the writer has found it commonly in the island of Vieques, 17 miles east of Porto Rico. Nothing is known of its occurrence in Jamaica, but Mr. C. H. Curran has recently described[7] from there a closely related parasite of *Diatraea saccharalis* under the name *Hypostena* (*Tachinophyto*) *grisea*. No host other than *D. saccharalis* is yet known of *L. diatraeae*.

Though there are occasional references in literature to the habits of this Tachinid, no definite studies appear to have been previously made upon its biology, which is strange, considering its importance in the Greater Antilles, especially Cuba and Porto Rico, and the fact that it has been introduced into several other countries. At Central Aguirre, on the south coast of Porto Rico, the writer had this insect under observation from February 1925 until early in 1927. The following notes are based upon field and laboratory studies made during this period.

Bionomics.

There is every reason to believe that *Lixophaga diatraeae*, like many other Tachinids, is larviparous. On one occasion (12.xi.26) an apparently freshly-deposited larva was found crawling over the thoracic region of a medium-sized larva of *Diatraea* discovered in the act of emerging from a young sugar-cane stalk. The borer with the attached parasite was put into a small glass vial and brought to the laboratory, where, upon examination, it was found that the Dipterous larva had disappeared within its host, which exhibited two small blackish sear-like patches upon the pleural region of the mesothorax, indicating where the mouth-parts of the contained parasite

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were embedded. The writer thinks that the parasite gained entry to its host by way of one of the thoracic spiracles. The borer was dissected under water and the Tachinid larva removed. It measured 1·7 mm. in length when fully expanded, but hardly more than 1 mm. when contracted; its breadth was 0·6 mm. After examination this larva was transferred to the thoracic region of another *Diatraea* larva, but, though alive and quite active, it failed to penetrate and was found dead in the tube the following day.

The fully-grown larva measures 5·0–6·5 mm. in length, and the puparium 3·5–5·0 mm. Puparia producing male flies are almost invariably smaller than those producing females.

By careful observation of large numbers of parasitised borers collected in the field and studied in the laboratory it was found that the larval period of the Tachinid was not more than 6 days, and any borers kept for this period and showing no signs

Lixophaga diatraeae, Towns. (x 10).

of the presence of the parasite can safely be considered as unparasitised. Though borers in an early stage of attack by *L. diatraeae* could generally be recognised by the presence of small black marks visible through the body integument, this was not always the case, for many borers, apparently quite sound and healthy when collected, showed signs of parasitism only after being kept under observation for three or four days.

The mature Tachinid larvae generally leave the host and form puparia in the latter's tunnel, but sometimes the puparia were found within the skin of a dead *Diatraea* larva or pupa. Complete chitinisation of the puparium seldom required more than 12 hours after the emergence of larvae from the host, and the period

between this taking place and the emergence of the adult fly was found (by averaging over 50 examples) to be 10·2 days, with maximum and minimum periods of 12·5 and 8 days respectively.

The adults generally emerged from the puparia during the early hours of daylight, there being few exceptions to this. When numbers of adults were bred from puparia reared in the laboratory from parasitised borers collected in the field, the proportion of the sexes was found to be about even. Mating was never observed among individuals in captivity, but was frequently noted in the field during early morning, presumably shortly after their emergence.

Nothing is known of the feeding habits of the adult flies in a state of nature, but in captivity they fed with avidity upon sweetened water or sugar-cane juice. The males rapidly died in cages, but the females have been maintained alive for six days, provided that food was given to them. Though attempts were made, it was never found possible to rear progeny from adults in captivity.

Generally one larva only of *L. diatraeae* is to be found in each parasitised borer, but it was not uncommon to breed two or more of the parasites from one host ; the resultant flies in such cases always proved to be small males. On one occasion three empty puparia were found in a burrow of *Diatraea* containing the remains of but one host larva.

Of any number of parasitised *Diatraea*, the majority would be found as larvae half-way through their development, though parasitism among nearly fully-fed larvae was not infrequent ; about 15 per cent. of the parasitised hosts would be pupae in various stages of development, and the evidence points to these having been attacked after pupation rather than that they had succeeded in pupating after being parasitised.

Natural Enemies.

Though several hundreds of larvae and puparia of *L. diatraeae* were collected from borer-infested sugar-canes in the field and kept under observation at Central Aguirre, no cases of hyperparasitism were noted, though it is difficult to believe this to be non-existent in Porto Rico. Mr. T. E. Holloway[2] records that in Cuba *L. diatraeae* has to contend with a secondary parasite, but gives no indication of its nature.

The common fire ant (hormiga brava) of Porto Rico (*Solenopsis geminata*, F.), was often found in *Diatraea* borings in sugar-cane, and on several occasions the remains of recently eaten puparia of *Lixophaga* were found, but these cases were probably quite accidental, and though considered noxious from some points of view, this ant is often beneficial owing to the numbers of young larvae of *Diatraea* and *Diaprepes* (weevil root borer) that it destroys.

Economic Status.

Parasitism by *L. diatraeae* occurs among borers in canes of all ages, though it was found possible to calculate the percentage of parasitism only in cases where borers occurred in young shoots, the presence of the pest being indicated by the drying-up of the central leaf-whorl, forming what is called a "dead-heart." The figures below refer to parasitism among borers taken from these dead-hearts and kept under observation for six days. It is believed that the percentage of parasitism is higher among borers infesting fully developed canes.

The amount of parasitism of *Diatraea* by *Lixophaga* varies greatly in different fields, and there appears to be a distinct seasonal variation, for whereas in February–March 1925 (when borers in dead-hearts were quite scarce) average parasitism was 12 per cent. (maximum 23 per cent.) of all borers, during October and November 1926 (when the occurrence of borers in young canefields was at its maximum), the

average was 37 per cent., and many fields were found with over 50 per cent. parasitism, the highest noted being 63 per cent. Referring to conditions in Cuba, Mr. Holloway[2] states " The writer estimated that from 20 to 50 per cent. of the moth borer larvae were parasitised, though in one small field the percentage was much higher."

It is to be regretted that no data are available for the autumn months of 1925 or the spring of 1926, to compare with the percentages given in the preceding paragraph, but if these figures represent the normal for their respective seasons (as there is every reason to believe), the conclusion is that the heavy parasitism among *Diatraea* at the time of its maximum abundance in young canefields (October to December) is partly, if not wholly, responsible for the scarcity of borers the following spring.

Lixophaga diatraeae is the only larval parasite of *Diatraea* of any importance in Porto Rico, though occasionally borers are found attacked by *Sarcophaga sternodontis*, Townsend, a species of wide neotropical distribution which attacks numerous Coleoptera, Hemiptera, and Orthoptera, as well as many species of several families of Lepidoptera.

With the recent establishment of the Braconid, *Microdus diatraeae*, Turner, on the south of Porto Rico, it is very probable that cases of super-parasitism will occur, when eggs of the Braconid may be deposited upon borers already parasitised by the Tachinid, or *vice versa*. There should, however, be nothing to fear from the competition of the two insects, as the total of parasitism by both species, if not equal to the sum of the parasitism by each separately, must be greater than that by either parasite alone.

The writer does not think that the efficiency of *Lixophaga* can be artificially increased in any way, as it seems that this parasite has reached its maximum effectiveness, there being a state of natural equilibrium maintained between it and its host. However, whenever borer control is practised by cutting out "dead-hearts" (as is the regular practice in British Guiana), some system should be adopted for preventing the destruction of the Tachinids. The writer, in experimenting towards this end, found that these flies, owing to their phototropic habits, could be saved when the dead-hearts were stored for 14 days in large wooden boxes through the sides of which glass jars or small wire cages were fixed. In large scale plantation work, an apparatus could be employed similar to that described by the writer in this Bulletin (xvi, 1926, p. 260) for similar work with Hymenopterous parasites of *Diatraea* in British Guiana.

Introduction into Other Countries.

In 1915 *Lixophaga diatraeae* was imported from Cuba into Louisiana, where the annual losses due to *Diatraea* sometimes exceed one-third of the sugar crop, by Mr. U. C. Loftin, working in co-operation with Mr. T. E. Holloway, of the United States Bureau of Entomology. Several shipments were despatched from Cuba, and numbers of the adult Tachinids were released in the neighbourhood of the Audubon Park Experiment Station. During subsequent years, recoveries were made of several individuals in the cane fields, proving their establishment, and also that the species could survive winter conditions in Louisiana.

Later, in 1918, a number of prominent cane-growers in Louisiana became interested and arranged for Mr. Holloway to go to Cuba to secure more of these parasites, and he succeeded in bringing over several hundreds of the Tachinids, about 33 per cent. of them arriving alive at New Orleans. In one of Mr. Holloway's reports[2] upon this work, he makes some interesting observations upon *Lixophaga*, placing it upon record that in Louisiana the insects passed through two, and perhaps three,

generations (whereas in Porto Rico it had probably 20 generations annually) and spent the winter in a dormant state. Mr. Holloway remarks, " On December 2nd one puparium was found in a field cage, but the fly did not emerge and it seems that the insect was dead. It is believed that other parasites are present within the host larvae and will emerge in the spring." From this, it seems that *L. diatraeae* can adapt itself to hibernating both as a larva within its host, and also as a pupa.

Of recent years one does not hear much about these Tachinids in Louisiana, where other methods are now being tried against the cane borer. It seems a pity that, since it was demonstrated beyond all doubt that the species could to some extent at least acclimatise itself to Louisiana conditions, further efforts were not made to bring over *Lixophaga* from Cuba during the spring, so that there might be larger numbers capable of surviving the winter and multiplying in the following year.

Considering the long time required for bringing into Louisiana (and elsewhere) material of this nature from Cuba, and the relatively small percentage (33 per cent., according to Mr. Holloway) of the parasites arriving alive at their destination, it seems to the writer that far greater success would be obtained by employing an aeroplane or seaplane for transport purposes, for by such means probably 100 per cent. of all parasites collected could be received rapidly and without undue hardship. In view of the great popularity of the use of aeroplanes in Louisiana for dusting the canes with poisons for the control of *Diatraea*, it seems quite logical to turn towards this modern means for securing prompt importations of beneficial insects when the distance is not great.

Interest in Louisiana has quite recently been taken in a recommendation put forward by the writer[11] that parasites of *Diatraea* should be introduced into that State from Tucumán, Argentina, a subtropical region where canes are grown under conditions very similar to those of Louisiana. In Tucumán there exist two Hymenopterous parasites, *Ipobracon tucumanus*, Brèthes, and *Microdus crossi*, Br., as well as a fly, *Sarcophaga diatraeae*, Br.* It seems that in view of the partial success secured in Louisiana with the distinctly tropical *Lixophaga diatraeae*, the chances are in favour of far better results following the importation of such parasites as those mentioned above, as they are already acclimatised to conditions like those of Louisiana.

In 1922 *L. diatraeae* was introduced from Cuba into N.-W. Mexico in an effort to control *Diatraea lineolata*, Walk. This work was carried out by Mr. R. H. van Zwaluwenburg, who in 1926 stated[5] that the parasites did not become established.

During his tour of service in British Guiana as entomologist to Messrs. S. Davson & Co., Ltd., the present writer recommended the importation into that country of *Lixophaga diatraeae*, with the result that in 1924 he was sent to Porto Rico to effect the introduction. An account of this work and its results was published in 1924 in a printed report[8] to the firm who financed it, and also in 1926 in this Bulletin.[9]

In each of the countries mentioned above, to which this Tachinid has been introduced from the Greater Antilles, a certain amount of acclimatisation to new conditions was necessary, and it may be that the apparent failure of the species to establish itself is due in some measure to a large percentage of the individuals not being readily able to adapt themselves to new climatic conditions. In the event, however, of the writer's suggestion being adopted, that *L. diatraeae* be used to control *Diatraea saccharalis* in Barbados and other West Indian islands, it is believed that this parasite would there find conditions quite similar to those of its natural habitat, and certainly this Tachinid seems to be a most promising enemy of the sugar-cane moth borer for establishment in that part of the world.

* See Bull. Ent. Res. xviii, pp. 205–207, 1927.

References.

1. Townsend, C. H. T. "Some New North American Muscoid Forms."—Insec. Insc. Mens., iv, pp. 73–78, 1916. (Abstract in Rev. Appl. Ent., Ser. A, v, p. 9, 1917.)
2. Holloway, T. E. "Parasite Introduction as a means of saving Sugar."—J. Econ. Ent., xii, pp. 175–178, 1919. (R.A.E., A, vii, p. 279, 1919.)
3. Holloway, T. E. "Establishing the Cane Borer Parasite from Cuba on Louisiana Plantations."—Louisiana Planter and Sugar Manufacturer, lxiv, p. 11, 3.i.20. (R.A.E., A, viii, p. 169, 1920.)
4. Van Zwaluwenburg, R. H. "Tachinids and Sarcophagids established in Mexico."—J. Econ. Ent., xvi, p. 227, 1923. (R.A.E., A, xi, p. 336, 1923.)
5. Van Zwaluwenburg, R. H. "Insect Enemies of Sugar Cane in Western Mexico."—J. Econ. Ent., xix, pp. 664–669, 1926. (R.A.E., A, xiv, p. 540, 1927.)
6. Aldrich, J. M. "Notes on American Tachinidae."—Insec. Insc. Mens., xii, pp. 145–149, 1924. (R.A.E., A, xii, p. 587, 1924.)
7. Curran, C. H. Appendix to "Catalogus Insectorum Jamaicensis," by C. C. Gowdey.—Dept. Agric., Jamaica, Ent. Bull., no. 4, 1926. (R.A.E., A, xv, p. 52, 1927.)
8. Box, H. E. "Report upon a Trip to Porto Rico, April–July, 1924."—S. Davson & Co., Ltd., Berbice, British Guiana, 1924. (R.A.E., A, xiii, p. 86, 1925.)
9. Box, H. E. "Sugar-Cane Moth Borers (*Diatraea* spp.) in British Guiana."—Bull. Ent. Res., xvi, pp. 249–266, 1926. (R.A.E., A, xiv, p. 101, 1926.)
10. Box, H. E. "Parasites of Sugar Cane Moth Borer (*Diatraea*)."—Reference Book of the Sugar Industry of the World, New Orleans, La., iv, pp. 49–52, 1926. (R.A.E., A, xiv, p. 547, 1926.)
11. Correspondence and Editorial in The Planter and Sugar Manufacturer, New Orleans, La., lxxix, no. 12, pp. 224–225, 227 (17.ix.27); no. 14, p. 267 (1.x.27).

AN EXAMINATION OF THE EFFICACY OF ARSENICAL SOLUTIONS IN THE RECLAMATION OF TSETSE AREAS.

By

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1. Introduction.

In October of last year the Acting Game Warden of Uganda, Mr. G. Maitland Warne, forwarded to one of us some newspaper cuttings that he had received from Dr. E. Warren, Director of the Natal Museum. These cuttings, from the *Natal Mercury* of 1st, 25th and 30th August, set forth an interesting correspondence about the tsetse-fly problem in Zululand, and embodied practical suggestions for control of the fly on a large scale. Some time before, Mr. Cooper, of Cooper's Dip fame, had visited us at Entebbe and discussed the possibility of carrying out experiments on the effect of feeding tsetse on animals regularly dipped in arsenical solutions, the question having been raised in South Africa whether dipping might not prove to be a practical means of controlling fly. At the time of Mr. Cooper's visit it was not possible to undertake the investigations desired, but the arrival of Mr. Warren's communication found us in a better position.

To those acquainted with the tsetse problem the simplicity of the remedy suggested in these interesting newspaper articles will come as something of a shock. Years of costly experience have convinced entomologists and others who have taken up arms against *Glossina* in different parts of Africa that the eradication of tsetse is at the best of times a costly, difficult and, generally, a heart-breaking problem. The more one learns about these flies, the more redoubtable they appear. Our first

impression, gleaned from a perusal of these articles, was thus frankly one of mild scepticism. The inferences hardly seemed justified by the evidence, and the whole thesis seemed too plausible and too good to be true.

At one time a discussion of a somewhat similar nature raged around the assertion that rinderpest destroyed tsetse. The observations and experience of many a pioneer and hunter of the old days in South Africa came for the first time on record, and much valuable information was accumulated about tsetse and their habits. That tsetse disappeared from fly-belts shortly after the rinderpest, there was no doubt. What led to this disappearance was not quite clear. Was it the destruction of the game and consequent failure of the fly's food-supply ; or did the rinderpest organism itself kill the tsetse ? Argument and debate cannot settle such points as these ; there must sooner or later be an appeal to direct properly controlled experiment. In the case of the rinderpest problem, experiment proved that rinderpest blood, *per se*, had no harmful effect on *G. palpalis* (Duke, 1919). Presumably, therefore, other species of tsetse are equally unaffected by this organism.* In the case before us it was obviously an easy matter to test the contentions advanced, and this we have accordingly done. It must be confessed that some of the results obtained were unexpected.

The procedure below is, first of all, to set down some of the criticisms suggested by a perusal of the correspondence. A brief resumé of relevant published experimental work on this subject is then given, and finally our actual experiments.

2. Extracts from Newspaper Correspondence about the "Nagana Problem."

The following are excerpts from articles on the Nagana Problem published in the *Natal Mercury* of 1st, 25th, and 30th August 1927.

The passages are numbered to facilitate subsequent reference to them in the text.

(i.) Quotation from letter from Sir Charles Saunders, who, as Chief Magistrate and Civil Commissioner, was actively associated with the administration of Zululand from 1888 to 1909. Dated 1.viii.27.

" The most significant and interesting feature in regard to the apparent disappearance of nagana from these areas is that it has been coincident with, or at least has closely followed, the introduction of cattle into the localities and the institution of their regular dipping in tanks erected within the areas.

" Although the large fauna was considerably reduced in number, an ample sprinkling of the varieties usually associated with the presence of tsetse fly still exists, grazing over the same ground and often among the cattle. Much thorn bush also still remains untouched, so that all hitherto known conditions favourable to the existence of fly are abundant."

This " until a few years ago was one of the most deadly zones to animals susceptible to fly infection."

" According to Native evidence, when the introduction of cattle commenced many deaths from nagana occurred, but gradually decreased until they became negligible, and they seldom, if ever, occur now.

" What can have eradicated the fly during the last few years in these areas, which to my certain knowledge were badly infested for many years previously, unless it is the maintenance of regular dipping of cattle within them and the consequent

*[It seems desirable to point out that entomologically this is a very unsafe conclusion. The more we have learnt about tsetse-flies, the more evident has it become that it is very unwise to assume that what is true of one species is necessarily true of any other. The reaction of *morsitans* or *pallidipes* to any given factor under natural conditions cannot be conclusively demonstrated, one way or the other, merely by experiments on captive *palpalis*.—Ed.]

poisoning of the insect, I cannot imagine. Moreover, it seems quite possible that on sucking the blood of cattle within limited periods after their dipping the fly are poisoned in the same manner as ticks are." He adds that other biting flies allied to tsetse have also disappeared since regular dipping was instituted.

(ii.) Letter from Sir Charles Saunders published 25.viii.27. Speaking of a conversation with a well-known and old Zululand settler, Mr. Young, Sir Charles Saunders writes: "In reply to further questions as to what he attributed the disappearance of nagana in that locality during recent years, he unhesitatingly and emphatically asserted that the disappearance of tsetse fly there was unquestionably due to the regular and proper dipping of his cattle which he attended to most strictly."

(iii.) Reference is then made to a native chief who brought his cattle, free from nagana, into an area a few miles from where Mr. Young lived. The native cattle began to die and were soon decimated.

"Meanwhile, Mr. Young's cattle, which were regularly dipped and grazed in the same locality, thrived."

(iv.) In other areas in Zululand "considerable herds of fat, healthy cattle are now to be found, when dipping is regularly and properly carried out, in areas which were deadly fly belts before dipping became general. These parts are . . . still frequented by game."

(v.) Letter from Dr. Ernest Warren, Director of the Natal Museum, published 30.viii.27.

"It might be said . . . that the minute traces of the dip poison, which may sometimes be detected in the blood of repeatedly dipped cattle, would be totally insufficient to kill a tsetse, but it would be extremely rash to assume that these minute traces of poison would be innocuous to the insect because they have no pernicious effect on the cattle. But this debatable point may be disregarded altogether, for the following observation would appear to demonstrate quite independently of the condition of the blood that the intensive dipping of cattle cannot fail to have a most prejudicial effect on the tsetse-fly population." Then follows a reference to Mr. R. H. Harris' observation that a tsetse will explore almost any moist surface with its proboscis, and that flies kept on blotting-paper moistened with arsenite of soda are rapidly poisoned. "Now if the ox has been dipped and the skin and hair are slightly damp with sweat or dew, as must often happen, the fluid will of necessity be somewhat strongly poisoned, and the tsetse could not fail to imbibe some of it while seeking a favourable place for drawing blood. The damp skin and hair impregnated with the dip differs in no essential respect from the poisoned blotting-paper used in the experiment mentioned above—where the tsetse died in less than one hour. It is clear that the habits of the tsetse are such as to make the insect extremely vulnerable to this method of attack, and it seems impossible to escape from the conclusion that the intensive dipping of cattle in a fly-infested region would in the course of time render that area free from fly and consequently safe from 'nagana' and Sleeping Sickness."

3. Critical Examination of the Case presented by these Extracts.

It is plain from the above quotations that there exists an opinion among certain experienced laymen in South Africa that the recession or disappearance of tsetse in certain parts of Zululand is due to the introduction in those areas of the practice of dipping. There is also a suspicion abroad, or perhaps we should say a hope, that a judicious combination of dipping and the use of poisoned dummies may prove a practical and effective means of exterminating *Glossina* on a large scale.

Sir Charles Saunders' evidence shows that an area formerly tsetse-infested now supports a large number of healthy cattle. Formerly, he says, cattle grazed in this area died of " nagana."

But it is not clear from Sir Charles Saunders' account that the tsetse had not already disappeared, or, at any rate, greatly diminished from all or part of the area he is citing before the cattle were introduced. In other words, that the hitherto unknown influences that lead from time to time to the disappearance of tsetse from fly-belts had already come into play, so that the cattle, when they arrived, merely encountered the rearguard of a retreating enemy. In this connection it is significant to read that the large fauna, *i.e.*, the fly's main food supply, was " considerably reduced " in number, although an " ample sprinkling " remained. Changes were thus taking place in the environment of the fly about this time, changes that may well have already upset the balance essential to its survival.

Native evidence testified that many deaths from " nagana " occurred when the cattle first arrived, but that the number gradually decreased, so that they seldom, if ever, occur now. All this is just what would be expected were the fly already leaving the area. The disappearance of tsetse from an area where game and scrub remain apparently unaltered has occurred in Uganda, and doubtless elsewhere. There are certainly two areas in Uganda where the tsetse infestation has entirely changed in recent years, though these areas are both apparently just as suited to the fly as ever in the past. In neither is there any dip, and domestic stock waxes and wanes according to the absence or presence of tsetse.

Our second point is this. Did the cattle die of " nagana " ; or did they die of East Coast Fever or some other tick-borne disease, or of a combination of a tick-borne disease and trypanosomiasis ? " Nagana " is the name given to trypanosomiasis of cattle. At one time it was held to be due to *T. brucei* ; it is now generally recognised that the most fatal trypanosomes of cattle are the members of the *congolense* group. Doubtless, certain strains of *T. brucei* are pathogenic to cattle ; but, generally speaking, this species is not nearly so dangerous as *T. congolense*. Multiple infections by two or more species of trypanosomes undoubtedly often occur, and are included under the name " nagana."

The fact that stock, grazing in an area where there are tsetse, dies, does not of itself justify the conclusion that " nagana " is the sole cause of death. Even if the cattle are actually found to be infected with trypanosomes it does not follow that the animals die of uncomplicated trypanosomiasis. There are ticks to be considered, and their evil effects both as irritating ectoparasites and as carriers of disease. Tick-infested cattle have a lower general resistance than clean animals. They lose condition, and condition plays an extremely important part in resistance to disease. Little is yet known of the rôle of game in the spread of piroplasmas pathogenic to cattle. But even if diseases such as East Coast Fever can definitely be excluded from the situation we are discussing, there remains the almost miraculous effect produced on tick-ridden cattle by a course of regular dipping. We have seen this effect at Entebbe, where the condition of the cattle, old and young, has improved enormously since the introduction of regular dipping by the Veterinary Authorities.

It is now a generally accepted fact that the resistance of animals to trypanosomiasis, *i.e.*, to " nagana," often depends very largely on their environment and standard of living. Poor food, hard work, heavy infestation with ticks, exposure to rain and cold, all contribute to a fatal disturbance of the equilibrium that so often exists between trypanosomes and their hosts.

To sum up on this point, there is good reason to believe that the destruction of ticks and the consequent improvement of the general condition that results will enhance the resistance of stock to " nagana." It must be remembered that the pathogenic trypanosomes of cattle vary in virulence, and that there are strains even

of *T. congolense* that are of very low virulence, while some strains of *T. brucei* are quite harmless to cattle. The better condition resulting from regular dipping may thus, in certain circumstances, easily turn the scale in favour of stock, especially if at the same time exposure to tsetse is diminishing.

Para. iii is interesting as it indicates that Mr. Young's cattle owed their survival to the direct action of the dip rather than to immunity from fly-bite, as both stocks were grazed in the same locality and came into contact with tsetse. This supports our contention that the good health of the cattle is explained by the general improvement of condition caused by dipping. It certainly does not prove that the fly was poisoned by feeding on dipped animals.

Para. iv describes exactly what one would expect when tsetse-bush is " reclaimed " and the fly has disappeared. As already pointed out, fly has been known to disappear from areas where no apparent change in fauna or flora is discernible. Such areas are eligible for reclamation, and can be kept permanently free from tsetse by the introduction of settlers and their stock and the civilisation that follows in their train. On the other hand, if left untouched and undeveloped, such areas may be reinvaded by fly. Why the tsetse go and why they come back is not always within our comprehension.

The evidence and arguments advanced in the articles we have been considering show that large tracts of country, once infested by tsetse and fatal to domestic animals, are now free from fly and supporting large numbers of cattle. It is equally plain that the stock in these parts of Zululand has derived great benefit from regular and systematic dipping. The further inference that the installation of these outpost dips has led directly to a destruction of tsetse seems to us unwarranted. It would seem rather that the gradual advance of civilisation into the wilderness has led to disturbances in environment inimical to tsetse. The game was disturbed and its numbers reduced by man's ever-encroaching activities. The construction of dips testifies to his firm foothold ; they helped to consolidate his gains. The cattle benefited enormously by the relief afforded by this treatment and multiplied apace, and the fly receded ever farther and farther into the undisturbed bush that still fringes the advance of organised settlement.

4. Résumé of Scientific Observations bearing on the present Investigations.

The practical proposals arising from the above correspondence are (1) arsenical dipping of cattle exposed to tsetse ; (2) the distribution of dummy animals, whose hides are impregnated with arsenic, through the fly-belts. Both these measures are directed against the tsetse. In addition, there is Bevan's suggestion that dipping in arsenical solutions has a restraining effect on animal trypanosomiasis. Let us now examine these propositions to see whether there is any direct experimental evidence that bears upon them.

In dry weather the skin of dipped animals dries very rapidly after the plunge—on a sunny day in Uganda half to three-quarters of an hour is sufficient. In rainy weather drying will be delayed, but some of the arsenic will be washed off the skin, and the flies will probably bite less readily under the weather conditions that determine delayed drying.

Harris has described *G. pallidipes* examining with its proboscis the skin of its victim before starting seriously to feed. The duration and extent of this preliminary examination presumably depend partly on the proximity and accessibility of a suitable capillary, and partly on the voracity of the insect. A hungry fly, alighting on an animal at a point where the hair is short, will not waste much time in such preliminaries.

Flies in captivity also exhibit this tendency to explore objects with the proboscis, even when no possible host is near. The insects wander slowly about their prison, testing the walls with the tip of the proboscis, which is lowered from the protecting palps by the same mechanism that operates during the actual insertion of the proboscis into an animal's skin. The hungrier the fly the more persistently it explores, and any disturbance of the box results in a renewal of the examination.

Harris (1923) has observed that tsetse (*G. pallidipes*), placed over blotting-paper soaked in arsenite of soda, are poisoned and die within an hour. He notes that this phenomenon is not due to fumes, but to direct imbibition of arsenic by the fly.

This observation is interesting in view of the uncertainty that still prevails about the feeding habits of tsetse. Thus, Roubaud (1919) maintains, as the result of a careful study of the digestive and reproductive systems of *Glossina*, that these flies take up no fluid but blood. Their pupiparous reproduction ; the peculiar physiology of the digestive processes in larva, pupa and adult ; and the presence, in the adult intestinal tract of an area of specialised epithelium containing symbionts mark these flies as bloodsuckers, pure and simple. According to Roubaud, the *Glossinae*, though not quite so highly specialised as certain of their wingless Hippoboscid relatives, are distinguished from the great majority of free-flying biting flies by their complete abstention from water or any other nourishment than blood. He writes " . . . les Glossines, dans les conditions naturelles, ne peuvent se nourrir que de sang prélevé à l'intérieur du corps des hôtes " (p. 509). Since the publication of Roubaud's paper, other observers have studied the dietetics of *Glossina*. Carpenter (1913) described various objects, apparently of vegetable nature, that he found in dissecting the alimentary tract of wild *G. palpalis* in Uganda. His figures include fragments of vegetable tissue ; yeast-like organisms ; a number of objects whose nature it is difficult to determine ; and, most important of all, an Ostracod. He concludes that " *Glossina* does suck up water " and that " Strong evidence has been obtained that it feeds on plant tissues." In the dissection of his flies Carpenter employed " pure rain-water collected into a stoppered bottle from off the tent roof, after this had been well washed in the heavy rain." It is thus possible that some of the bodies figured in this report came from the water or from air-born dust. Examination of dust in and outside this laboratory soon revealed minute pieces of vegetable tissues similar to some of those shown in Carpenter's figures. Others of the objects figured might conceivably have obtained access to the fly's interior through the spiracles. But when allowance has been made for all possible fallacies the presence of the Ostracod, as Newstead observes (1924), is strong evidence that the fly in nature on occasion takes up water.

Yorke and Blacklock (1915) found that *G. palpalis* in captivity would not take up shed blood or any other fluid, save through a membrane. Through a membrane their flies took up, more or less readily, normal saline, or a solution of haemoglobin in distilled water ; solutions of sugar, NaCl or glycerine, in water containing dye, were also taken up, but less readily than blood. These authors accept Carpenter's evidence that the fly takes up vegetable juices in nature. They saw *G. palpalis* repeatedly plunge its proboscis into fruits, but never obtained any evidence that the fly was feeding when so doing. They conclude by saying " We are of opinion that *G. palpalis* in nature may under certain circumstances take up fluid other than blood."

Another significant piece of evidence on this question was produced by Lloyd, who in 1910 discovered in two of about 200 wild *G. palpalis* the larval form of the free-living Nematode *Mermis*. The eggs of this worm are deposited on grass, and are normally taken up by the insects in which the larval stage is passed, *i.e.*, grass-hoppers, etc. How then did these *Glossina* pick up their relatively enormous parasites ? Specimens of *Mermis* have since been reported on one or two occasions from *G. palpalis* in Uganda.

So much for the available published evidence that *Glossina* take up substances other than blood.

The fact that the members of the *vivax* and the *congolense* groups of pathogenic trypanosomes in the insect intermediary have their anterior station in the proboscis of *Glossina* proves that the lumen of the proboscis of these flies always contains fluid. This fluid is presumably supplied by the salivary glands.

This conclusion is of interest in considering the means by which a tsetse can take up arsenic from wet blotting-paper. What is the object of the fly in making a careful exploration with its proboscis of the sides of its cage? Is it that, impelled by blind optimism, the hungry insect hopes to detect hidden away in the wood a concealed blood-vessel; or is it just scouring the surface for adventitious nourishment? If this last is true, then we may assume that a tsetse is taking up minute quantities of soluble surface-matter whenever it explores its surroundings with its proboscis. The amount of material taken up will depend to some extent on the length of time the palpation continues. If, however, this examination by the tip of the proboscis is merely a search for a convenient point of entry into an imaginary capillary, so that the fly may get a meal of its normal food, then the expectations of successfully attacking the tsetse by this channel in nature are very poor. Observation has shown that once a fly has alighted on an animal in nature it does not take long to insert its proboscis into the skin and either start feeding at once or, if dissatisfied with the first attempt, "bite" again immediately. The distinction between "probing" and "exploring" is important, as will be seen when we come to consider our experiments. Instructive in this respect is the behaviour of captive *G. palpalis* when preparing to feed on a *Varanus*. The fly first palpates the skin several times with the tip of its proboscis; then, down goes the head and the proboscis is buried in the animal. Sometimes the fly is successful at the first attempt and its abdomen gradually distends. Often, however, the first thrust fails to reach a vessel, and we see the fly withdraw and reinsert the proboscis hard by, once or perhaps several times, before it is comfortably installed.

On the other hand, if it is habitual for the fly, in its spare moments, to "lick" objects upon which it settles, then the result of the blotting-paper experiment suggests that in certain circumstances, the exact definition of which will require a great deal of laborious study, tsetse may be susceptible to poisons on a large scale in their natural environment.

On general grounds, it is highly probable that the exploratory palpation exhibited by captive tsetse is merely an endeavour on the fly's part to find blood. Flies in captivity will follow a finger moving across the wire of their cage, the proboscis lowered and feeling the way; the moment it gets a chance, the fly settles down and plunges the proboscis through the skin. Once it has settled on an animal, a hungry tsetse's one idea is to pierce a capillary; and it is difficult to believe that a fly whose movements are unhindered will submit living skin to anything like the thorough examination that proves so fatal on the arsenical blotting-paper.

5. Experiments with Tsetse and Arsenical Solutions.

We will now consider some actual experiments performed to test these assumptions.

These experiments were designed to examine from a practical point of view the questions raised. Thus wet and dry surfaces have each been examined, and Cooper's Dip, in ordinary and in double strength, has been used as a test arsenical solution.

(*a*) *On the Amount of Arsenic deposited in the Skin of a dipped Animal.*

Watkins-Pitchford, in a pamphlet on Tick Destruction by Dipping published by P. Davis & Sons, Natal, estimated the amount of arsenic found on the hides of

dipped animals. Some years later Green and Dijkman repeated this work and came to the conclusion that Watkins-Pitchford's figures " were much too high " (Green, 1918).

The following Table is reproduced from Green and Dijkman's paper. These authors point out that the earlier figures are from 40 to 70 times greater than their own, and the only difference between the treatment of the animals was that their cattle were dipped in plain aqueous arsenite of soda (0·16 per cent. As_2O_3), whereas in Pitchford's dip soap and paraffin were also present.

Pitchford's analyses.				Our own analyses [Green and Dijkman].					
Frequency of dipping.	Period elapsing since last dipping.	Grams As_2O_3 per sq. ft.		Frequency of dipping.	Period elapsing since dipping.	Grams As_2O_3 per sq. ft.			
		Hair and scurf.	Hide.			Hair and scurf.	Total	Hide	
								Epidermis.	Connective tissue.
Every five days for several months, last sprayings every 3rd day.	1	0·527	0·224	Every 5 days for three months.	1	0·085	0·0041	0·0026	0·0015
Every five days for several months.	5	0·352	0·251	ditto.	6	0·051	0·0035	0·0020	0·0015
Regularly for several months.	10	0·260	0·137	ditto.	14	0·030	0·0033	0·0019	0·0014

In view of these results it seemed to us advisable to make a few independent observations.

Four samples of skin were examined. In every case the piece of skin received for examination was first weighed and its area measured. It was then shaved, and the scurf and hair so removed were weighed. Hair and shaved skin were treated separately.

A process of wet combustion was adopted, and hydrochloric acid with potassium chlorate was employed. On completion of the combustion the solid débris was removed by filtration, and the filtrate, after removal of free chlorine, made up to 200 cc. with distilled water.

The solution thus prepared was then examined qualitatively and quantitatively for arsenic. An aliquot portion was taken and, of this, one cc. was submitted to a modified Gutzeit test, an indication being thus obtained of the total amount of arsenic present. The remainder of the portion removed was treated by Marsh's method, and the presence of arsenic confirmed by the formation of the characteristic film of elemental arsenic and the subsequent production of crystals of arsenious oxide and the yellow sulphide.

The bulk of the solution was then treated with zinc and hydrochloric acid in a suitable flask, and the arsenuretted hydrogen carried over into an absorption-apparatus consisting of two long stout test-tubes containing an excess of silver nitrate solution. A roll of dry lead acetate paper was interposed between the hydrogen generator and the tubes to hold back any hydrogen sulphide. The passage of the hydrogen was maintained for an hour, this period having been found more than sufficient to allow all the arsenic to be absorbed.

The silver solution, containing the arsenic as arsenious acid, was treated with a slight excess of hydrochloric acid, and the resulting precipitate of silver chloride removed by filtration. The filtrate after the addition of the requisite amount of sodium bicarbonate was titrated with $\frac{N}{100}$ iodine in the presence of starch. Immediately before use, the $\frac{N}{100}$ iodine was standardised by a freshly prepared solution of purified As_2O_3.

Results of Analyses—

	Area.	Weight.	As_2O_3 in milligrams per sq. ft.
Calf No. A (dipped 7 times) :			
Shaved skin	27 sq. ins.	48·3 grams.	1·49
Hair and scurf		1·5 ,,	5·96
Calf No. B (dipped 3 times) :			
Shaved skin	48 sq. ins.	51·0 ,,	2·89
Hair and scurf		1·25 ,,	4·73
Calf No. C (dipped 3 times) :			
Shaved skin	60 sq. ins.	71·0 ,,	2·64
Hair and scurf		1·74 ,,	5·55
Calf No. 59 (*cf.* below) : ...			
Shaved skin	20 sq. ins.	27·4 ,,	6·02
Hair and scurf		0·9 ,,	12·06

The figures correspond closely to those obtained by Green and Dijkman, and tend to confirm the opinion of these two workers that Pitchford's estimate was inordinately high.

The difference, in the two sets of examinations, between the amounts of arsenic found in the hair and scurf can probably be explained by the difference in the length and thickness of the hair of the two types of cattle, Uganda and South African respectively. Green and Dijkman do not give the weight of the material they examined.

The most important of these results is that given by Calf No. 59. This animal, as will be seen, was fed upon alternate days by boxes of *G. palpalis*. The dipping was very vigorously carried out, to the point where scorching appeared on the skin of the chest and belly. At this point dipping was stopped, and, under chloroform, a strip of the animal's skin was removed for analysis.

Comparison with Green and Dijkman's figures shows that the skin of calf No. 59 was relatively heavily impregnated with arsenic, so that this animal may be considered an excellent example of a well-dipped ox.

(*b*) *The Result of Feeding* G. palpalis *on an Animal whose Skin is well impregnated with Arsenic owing to intensive Dipping.*

Calf 59 had been dipped regularly twice weekly for some months before these experiments began. The fluid in the dip was examined at regular intervals and, if necessary, brought up to strength. From 21.x.27, the dip having been brought up to strength (1 in 300), the animal was dipped daily until 7.xi.27. On the 7th slight signs of scorching of the skin were noticed. The animal was dipped on the 9th and 11th November 1927, and dipping was then stopped. A portion of the skin was resected on the 16th November, under chloroform, and examined for arsenic (*cf.* above).

The following feeding experiments were made on the calf. The flies were fed on the calf every alternate day, a day's starvation being interposed between the feeds. After 15.xi.27, calf No. 59 was placed on the sick-list, and bull No. 100, which had been dipped regularly for many months, was employed in its place. The protocols of the experiments are given below and show only the mortality of the flies. They were put on the calf from half to three-quarters of an hour after its plunge through the dip, by which time most of the skin was dry. The flies were fed on the dried skin of the shoulder.

Experiments 708 *and* 709.

Clean flies bred in the laboratory and fed on calf 59 for the first time on 22.x.27.

Date.	*Experiment* 708.	*Experiment* 709.
23rd Oct. ...	3	2
24th ,, ...	4	0
25th ,, ...	2	1
26th ,, ...	1	2
29th ,, ...	1	1
30th ,,	0	1
31st ,, ...	2	2
1st Nov. ...	0	1
2nd ,, ...	1	2
3rd ,, ...	1	0
5th ,, ...	0	1
7th ,, ...	0	1
8th ,, ...	0	2
17th ,, ...	1 (fed on bull 100)	2 (fed on bull 100)
18th ,, ...	0	2
19th ,, ...	1	0
22nd ,, ...	Experiment ended ; flies remaining alive, dissected=14♂ 12♀=26.	Experiment ended ; flies remaining alive, dissected=11♂ 15♀=26.
	(During this expt. 5 immature larvae were extruded.)	(1 immature larva extruded.)

In considering the death-rate of the flies in these and the following experiments it must be realised that almost invariably during the first few days of their assemblage in the experimental boxes some of the flies die without ever having fed. Comparing the death-rate in these two experiments with that normally occurring among experimental flies at this laboratory—flies, that is to say, which have never been exposed to arsenic—it is clear that the arsenic present in the skin of calf 59 had no appreciable effect on their health. A paper shortly to appear in the "Annals of Tropical Medicine and Parasitology" deals with the normal death-rate of flies under the experimental conditions obtaining at this laboratory, and reference to that work will confirm the above statement. The survival to the 30th day of the experiment of 58 per cent. of the 89 flies employed confirms this assertion ; during these 30 days these 52 survivors fed some 15 times on animals whose skin was heavily impregnated with arsenic.

Experiments 729 and 732.

First fed on calf 59 on 31.ix.27, and thenceforth fed on alternate days. From 16th to 20th October the flies of these experiments fed on three occasions on a fowl; they were then fed on alternate days on bull 100.

Date.	*Experiment* 729.	*Experiment* 732.
4th Oct. ...	1	0
8th ,, ...	1	3
16th ,, ...	0 (fed on cock)	
18th ,, ...	0 ,,	
19th ,, ...	0 (starved)	1
20th ,, ...	2 (fed on cock)	0
21st ,, ...	0 (fed hereafter on bull 100)	
22nd ,, ...	1	0
24th ,, ...	0	1
26th ,, ...	1	0
27th ,, ...	1	0
29th ,, ...	1	0
30th ,, ...	0	1
1st Nov. ...	1	3
2nd ,, ...	1	2
3rd ,, ...	2	0
4th ,, ...	5	1
5th ,, ...	Experiment ended; flies remaining alive, dissected=11♂ 7♀=18.	Experiment ended; flies remaining alive, dissected=14♂ 9♀=23.

In these experiments 67 per cent. of the flies lived until the 30th day of the experiment.

In the next experiment a control was employed. In Experiment "A" the flies were fed on alternate days on bull 100. In Experiment "B," the flies fed on alternate days on a clean goat that was never dipped or in any way treated with arsenic. The first feeds took place on 15.xi.27.

Date.	*Experiment 'A'* (As).	*Experiment 'B'* (Control).
17th Nov. ...	2	2
18th ,, ...	0	6
19th ,, ...	1	7
20th ,, ...	1	1
22nd ,, ...	6	0
23rd ,, ...	1	0
24th ,, ...	4	2
25th ,, ...	1	2
28th ,, ...	4	1
29th ,, ...	0	3
30th ,, ...	0	1
2nd Dec. ...	Experiments ended; flies remaining =38	alive, dissected =19

These experiments were terminated after 15 days: in "A" 65 per cent. and in the control of 43 per cent. of the flies were alive on this day.

So far as one can see, these experiments constitute a fair test of the effect on tsetse of feeding on a dipped animal. The animals were well dipped; in the case of calf 59 a relatively very large amount of arsenic was actually proved to be present in the skin (the piece of skin removed from the animal for examination was taken from

the shoulder close to the actual place on which the flies fed). Calf 59 had more arsenic in its skin than either of the three animals examined by Green and Dijkman, although these authors were using a dip roughly twice as strong as ours. Moreover, the occurrence of scorching indicates that its skin was charged to its utmost capacity, the intensive dipping of the last few days being the culmination of a long series of twice weekly dippings. It will be noted, in connection with what follows, that the flies were fed on the skin after it had dried. The flies were feeding through the wire-gauze side of their cage, and were thus at a slight disadvantage compared to a free-moving wild insect. The handicap imposed on the tsetse by the pressing down of the animal's hair by the wire gauze would in all probability necessitate more preliminary palpation than would occur in nature.

Of interest at this stage are the experiments performed in Uganda in 1912 with arsenphenylglycin and *G. palpalis*. It was then found that flies fed on monkeys 24 hours after the animal had received subcutaneously 0·1 grm. of this drug took no harm, although there was sufficient arsenic in the imbibed blood to destroy flagellates developing in the mid and hind-gut of the fly (Duke, 1912).

6. Experiments to ascertain the Extent to which *G. palpalis* is susceptible to Insecticide Poisons spread on the Surface on which it alights.

Harris (1923) found that *G. pallidipes* were poisoned within an hour when placed on blotting-paper moistened with a solution of sodium arsenite.

The following experiments were carried out at this laboratory. The cages used have wooden ends and sides, with wire-gauze on the top and bottom ; they measured 6 in. by 4 in. by 3 in.

Experiment I.

Into a cage containing 20 flies a strip of blotting-paper, moistened with a 5·5 per cent. solution of sodium arsenite, was introduced.

Observation : Flies all dead within 24 hours.

Experiment II.

As above, but the blotting-paper allowed to dry before being placed in the cage.

Observation : 20 per cent. of the flies died in the first 24 hours ; 60 per cent. after 48 hours ; and the remaining 20 per cent. after 72 hours.

Experiment III.

As in *II*, but blotting-paper removed after 24 hours.

Observation :

	24 *hrs.*	48 *hrs.*	72 *hrs.*	*Surviving.*
Deaths in arsenic box	3	3	8	5
,, ,, control	0	2	3	6

Experiment IV.

Non-absorbent paper soaked in a 5·5 per cent. solution of sodium arsenite and dried before introduction into the cage.

Observation :

	24 *hrs.*	48 *hrs.*	72 *hrs.*	*Surviving.*
Deaths in arsenic box	0	8	8	4
,, ,, control	0	2	3	6

Experiment V.

Three wild flies were in turn held between the finger and thumb, and the tip of the proboscis introduced just below the surface of a solution of 5·5 per cent. solution of sodium arsenite.

Observation :

	24 *hrs.*	48 *hrs.*	72 *hrs.*	96 *hrs.*	*Surviving.*
Deaths among arsenic trio	1	0	0	0	2
,, ,, control trio	0	0	2	1	0

Experiment VI.

Repetition on a larger scale of Experiment V.

Observation :

	24 *hrs.*	48 *hrs.*	72 *hrs.*	*Surviving.*
Deaths with arsenic	4	4	1	0
,, ,, control	3	3	3	1

The above experiments, wherein the flies were exposed to a very strong arsenic solution, show that *G. palpalis* can take up arsenic in fatal quantities from a moist or from a dry surface, in the peculiar conditions obtaining during these experiments.

We will now pass on to an examination of the effects of Cooper's Dip.

Experiment VII.

Blotting-paper moistened with 1-300 solution of Cooper's Dip introduced into a cage of flies.

Observation : All flies dead within 24 hours.

Experiments VIII & VIIIa.

Blotting-paper moistened with 1-300 and with 1-150 solution of Cooper's Dip and dried before introduction into the cage.

Observation :

	24 *hrs.*	48 *hrs.*	72 *hrs.*	96 *hrs.*	*Surviving.*
Deaths in arsenic box 1-300	0	10	8	2	0
,, ,, ,, ,, 1-150	2	9	5	4	0
,, ,, control	0	4	4	5	4

Experiment VIIIb.

Blotting-paper moistened with 10 per cent. solution of Na_2CO_3.

Observation ; No apparent ill effect on the flies.

Experiment IX.

Flies placed in a cage containing a small dish of 1-300 solution of Cooper's Dip.

Observation : All dead within 24 hours : many of the dead flies lying in the fluid.

Experiment X.

Flies in a series of cages were confronted with the following substances, either dry on blotting-paper or in solution on moistened blotting-paper : starch, ferric carbonate, methylene blue, alizarin, charcoal and lead acetate.

Observation : The flies were examined by dissection and micro-chemical examination of the gut. Only the intestine behind the proventriculus was examined. No evidence was obtained that any of the substances employed had reached this region of the alimentary tract.

We will now consider experiments performed with arsenic and other solutions exploited on the living animal, the cage of flies being placed over the anointed patch of skin, and the flies feeding through the wire-gauze.

These experiments, as we shall see, possess a real practical significance.

Experiment XI.

A suitable area of skin over the scapula of goat, where the hair was thick, was soaked with a 5·5 per cent. sodium arsenite solution. The solution was thoroughly rubbed in with a wad of wool, and the skin was finally soused with the fluid immediately before the box was applied. A second goat was treated in the same way, but the skin was allowed to dry before the flies were applied.

Observation : The flies on the dried skin all fed to the full. After 24 hours there was one dead fly in this box, and 19 survivors.

The flies put on the wet skin had greater difficulty in feeding, owing doubtless to the difficulty in penetrating the matted pressed down hair. After 24 hours there were 10 dead flies in this box and 6 survivors.

Dissection of the ten dead flies showed that six contained a small number of fresh goats' blood corpuscles—that is to say, they had had a partial feed ; three were empty, and one contained human blood (supplied by the fly-boy who had caught them, in all probability).

The six living flies were then chloroformed and dissected. All contained a large amount of goat's blood, having had practically a full feed, and one contained the remains of an equally copious meal off the fly-boy.

Evidently, then, those flies that succeeded without trouble or delay in getting through the skin to the blood-vessels took no harm. Those, on the other hand, that were hampered in their efforts at feeding, and that were, in consequence, constrained to indulge in palpations and probings in their endeavour to feed, were poisoned.

This experiment was repeated on several occasions with various minor modifications, and the conclusion was inevitable that as long as the flies were able to feed freely they were in no way inconvenienced by the presence of arsenic, either dry or in solution, on the skin through which they took their meal. If, however, feeding was obstructed, the insects in their persistent efforts to find a passage were easily poisoned by any of the solutions of arsenic used above. On the other hand, the risk of poisoning was reduced enormously, if not completely eliminated, when the anointed skin was dry when the flies fed. In such circumstances they appeared to feed with absolute impunity, irrespective of the strength of the arsenic solution used.

These results are in keeping with the experiments already described above with calf 59.

Experiment XII. On the mechanism by which the fly takes up arsenic from a surface on which it alights.

A suitable area of skin on the side of the abdomen of a calf was soaked with a strong aqueous solution of methylene blue. The hair in this region was relatively long and thick. A cage of flies was placed on this stained area, while the hair and skin were still thoroughly wet with the solution.

Every few seconds the box was lifted off the skin and immediately replaced, so that the flies were forced to palpate and test the skin repeatedly and were unable to start feeding properly. This prevented imbibed blood from cleaning the proboscis of traces of methylene blue, should any be taken up.

After 24 hours there were no dead flies in the box. All were now chloroformed, and the proboscis of each examined for traces of methylene blue.

Observation : 20 flies had no traces of methylene blue on or in their proboscides. In four of these there was a very small number (say 5 or 6) of red blood cells of the calf visible in the lumen of the proboscis.

In 16 flies traces of methylene blue were visible on or in the proboscis. In the majority of these flies the stain was confined to one or more small epidermal scales that were sticking to the outer surface of the tube, to the labrum or to the labium, some at the tip, others at various points along the organ. In ten of these sixteen flies blood corpuscles of the calf were seen in the lumen. In several instances the stained scales were adhering to the edge of the labium, a portion coming into contact with the fluid in the lumen.

In five flies, all of which showed calf blood cells in the lumen of the proboscis, there was a definite blue staining of the column of fluid in the lumen of the proboscis and of the blood cells suspended in this fluid. In three of these five flies the staining was diffused through the fluid ; but in the other two there was a circumscribed and deeply stained patch about half-way up the lumen of the proboscis. Under the microscope, when intermittent gentle pressure was applied to the coverslip, this stained patch rapidly became paler and paler as the movement of the column of fluid in the lumen of the proboscis gradually carried away the stain, until finally no trace was discernible.

These observations show how foreign organic substances may be taken up by the fly from surfaces that are subjected to examination by its proboscis.

Discussion and Conclusions.

The above experiments suggest the following general practical conclusions :—

(1) Sufficient arsenic to kill the fly can be taken up by a *Glossina palpalis* during the examination by its proboscis of an impregnated surface.

(2) A fly can take up poisonous doses of arsenic from either a wet or a dry impermeable surface. This it does by palpating and testing the surface with its proboscis, by which means minute but fatal quantities of arsenic are imparted to the fluid contents of the proboscis-tube whence they are sucked up, " swallowed," and absorbed.

(3) When, however, the vehicle for the poison is the skin of a living animal the risk run by the fly is enormously reduced. The natural precision and skill of the insect enable it, in such circumstances, to reach the underlying blood-vessels without exposing itself to any serious risk. It is possible that the exploratory examination to which a hungry fly will sometimes subject a dead and impermeable surface is a different process from the brief preliminary inspection made by a tsetse resting on the living skin. In other words, the proximity of blood may stimulate a different reflex mechanism, and give rise to a " positive " rather than a " negative " movement of the column of fluid in the proboscis. This we do not know. In any case, we believe that in nature a fly will be able, with almost perfect impunity, to extract blood from a living animal, however heavily the skin of that animal is saturated with arsenic. If the skin is wet with the arsenical solution the risk is greater than when it is dry. In the latter case, we believe the chances of the fly being poisoned during the act of feeding to be practically negligible.

(4) There remains the suggestion to employ dummies impregnated with arsenic. This is a proposal that demands further examination in the natural surroundings of the fly. The truth cannot be reached by experiments with captive flies.

It is a matter of common observation that tsetse will often settle on and around an observer without attempting to feed on him. Harris has shown that they will settle on dummy animals and that they are attracted by sight. But the fly presumably has other senses which will enable it to detect the essential shortcomings of the best constructed dummy. It is generally admitted that tsetse know a dead from a live

animal, and will not attempt to obtain blood from a corpse even shortly after death. Are we, then, to suppose that they would remain long in doubt about the nutritive value of the dummy ? And can we be sure that their very presence upon it is not incidental, and due, partly, at any rate, to an idle interest in the hot-blooded observer and to the presence in his proximity of an agreeably coloured convenient resting place ? It is difficult to imagine a voracious fly vainly trying to bite a dummy animal while an observer stands by untouched. This might conceivably happen with *G. pallidipes*, but bitter experience with *G. morsitans* makes one sceptical about the gullibility of that species. And if the dummy is left alone in the bush, is the intelligence of the *Glossinae* so feeble that they will be deceived to the point of active investigation of the trap ? The mere presence of the fly around the dummy does not mean that any of the insects will attempt to feed on it. Tsetse often sit on the path in front of a pedestrian, and on trees and leaves round about him, without manifesting any sign of hunger.

However, this is all mere speculation, and if proof can be adduced, then the method will be worth developing. In pondering on the attraction for the fly exerted by moving objects one is tempted to give imagination rein and picture a trolly-line and a regulated service of arsenic-soaked dummies through the fly-bush. Movement would undoubtedly enhance the intensity of the deception, and this, together with the warmth of a tropical sun, might add greatly to its efficiency.

Meantime we withhold judgment, and rest confronted with the somewhat bizarre conclusion that, of the two alternative proposals for the destruction of tsetse on a large scale, the dummy is more likely to succeed than the dip.

7. On the Effect of Dipping on Trypanosomiasis of Stock.

Bevan, as the result of experiments carried out with guineapigs infected with trypanosomiasis, found reason to believe that " the dipping of guineapigs infected with trypanosomiasis, in arsenic-containing solutions of certain strength and at certain intervals, brings about the disappearance of trypanosomes from the peripheral blood. The parasite, however, is not eliminated since, when dipping is discontinued, it again reappears after a longer or shorter interval, and the disease thereafter runs its usual course, as if never interrupted " (Bevan, 1926).

He found that with a 1-300 solution of Cooper's Dip no effect was produced. With a solution of 1-156, positive results were obtained.

The following experiments were carried out to see the effect of a 1-300 solution, the usual strength employed in dips, with cattle infected with trypanosomiasis. This strength is weaker than the minimum found by Bevan to be efficacious with his guineapigs ; but the response of our calf 59 to dip of this strength suggests that in practice it would be dangerous to employ a stronger dip on a large scale for cattle.

Each animal was examined daily ; at each examination 50 stained fields were searched under a 2 mm. apoc. Zeiss and a No. 2 ocular. The trypanosomes seen are shown under three headings, *T. vivax*, *T. congolense* and *T. brucei*.

Bull 56.

This clean animal was sent to Buvuma Island, Victoria Nyanza, on 30.iii.27. There it was exposed to wild tsetse until 9.x.27, when it was brought back to Entebbe. Previous to 9.x.27, the animal had not been dipped ; from that date on it was dipped regularly three times a week until the end of February, when dipping was stopped. The results of examination of this beast's blood are shown below. Only days when trypanosomes were found in the 50 fields examined are shown in this schedule ; negative days are omitted.

Date.	Trypanosomes seen :		
	vivax	*brucei*	*congolense*
18.x.27	1	—	4
19.x.27	1	14	42
20.x.27	—	—	2
21.x.27	2	6	28
22.x.27	2	3	12
23.x.27	1	10	28
24.x.27	—	—	7
25.x.27	—	—	2
26.x.27	1	—	6
27.x.27	1	1	6
5.xi.27	—	—	6
6.xi.27	—	1	—
7.xi.27	2	1	1
8.xi.27	3	—	1
9.xi.27	—	—	2
10.xi.27	2	3	2
11.xi.27	1	—	4
12.xi.27	—	1	—
13.xi.27	6	3	2
14.xi.27	5	6	11
15.xi.27	4	—	8
16.xi.27	2	—	4
17.xi.27	—	—	3
18.xi.27	1	—	10
27.xi.27	—	—	1
28.xi.27	—	—	20
30.xi.27	—	—	1
1.xii.27	—	—	1
3.xii.27	—	—	4
9.xii.27	1	—	1
12.xii.27	—	1	—
15.xii.27	—	—	1
16.xii.27	—	—	18
17.xii.27	—	—	19
18.xii.27	—	—	4
22.xii.27	—	—	8
23.xii.27	—	—	11
24.xii.27	—	—	4
25.xii.27	—	—	20
26.xii.27	—	—	10
27.xii.27	—	—	5
29.xii.27	—	—	14
4.i.28	—	—	9
8.i.28	—	—	4
9.i.28	—	—	5
10.i.28	—	—	5
11.i.28	—	—	50
12.i.28	—	—	50
13.i.28	—	—	35
14.i.28	—	—	5
18.i.28	—	—	5
19.i.28	—	—	10
22.i.28	—	—	15
24.i.28	—	—	30
25.i.28	—	—	20
4.ii.28	—	—	1
5.ii.28	—	—	1
6.ii.28	—	—	3
8.ii.28	—	—	5
12.ii.28	—	10	5
13.ii.28	—	—	15
16.ii.28	In poor condition : prognosis bad.		
16.iii.28	Condition has greatly improved : appears on the road to recovery.		

It in interesting to see how *T. vivax* and *T. brucei* soon became rare in the peripheral blood, whereas *T. congolense* predominated throughout. Experience in Uganda points to *T. congolense* as by far the most dangerous species for cattle. *T. vivax*, *T. uniforme*, *T. brucei* often appear to do no harm to the domestic ruminants.

Bull 79.

Also sent, clean, to Buvuma Island, where it became infected with the same three species of trypanosomes as Bull 56. Returned to Entebbe on 9.x.27. Last dipped on 30.iii.27. Dipping recommenced on 20.x.27, and continued regularly three times weekly. The animal reached Entebbe in very poor condition, improved in health after a time, but suddenly began again to lose condition and died on 3.xii.27, the *post-mortem* lesions being typical of trypanosomiasis.

The following are the results of the daily examinations of 50 fields of stained blood of Bull 79. Negative days are omitted.

Date.	Trypanosomes seen :		
	vivax	*brucei*	*congolense*
18.x.27	—	—	15
19.x.27	—	—	15
20.x.27	—	—	5
21.x.27	—	—	2
22.x.27	—	—	6
23.x.27	—	—	2
26.x.27	—	—	4
28.x.27	—	—	3
31.x.27	—	3	4
3.xi.27	—	—	5
4.xi.27	2	4	2
5.xi.27	1	6	2
6.xi.27	—	1	2
7.xi.27	—	2	6
8.xi.27	1	3	8
9.xi.27	2	2	1
10.xi.27	—	3	—
11.xi.27	1	1	5
13.xi.27	—	—	4
14.xi.27	—	3	6
15.xi.27	52	13	57
16.xi.27	5	3	10
17.xi.27	—	—	1
18.xi.27	9	5	35
19.xi.27	—	—	2
20.xi.27	—	—	2
21.xi.27	1	1	3
22.xi.27	3	—	4
23.xi.27	—	—	7
24.xi.27	—	—	5
25.xi.27	—	—	5
26.xi.27	3	—	3
27.xi.27	—	—	3
29.xi.27	—	—	1
30.xi.27	—	—	1
1.xii.27	2	—	4
2.xii.27	—	—	2

Bull 117.

Healthy clean animal, inoculated subcutaneously on 20.x.27 with 10cc. fresh blood from Bull 56. Until 20.x.27 had been dipped regularly twice a week. From 20.x.27 dipping was stopped.

On 28.x.27 *T. brucei* and *T. congolense* found in blood for the first time.
On 30.x.27 *T. vivax* first appeared.
The results of daily examinations were as follows :—

Date.	Trypanosomes seen :		
	vivax	*brucei*	*congolense*
28.x.27	—	2	4
29.x.27	—	20	27
30.x.27	10	40	80
31.x.27	10	40	50
1.xi.27	3	14	33
2.xi.27	4	17	29
3.xi.27	2	8	10
4.xi.27	15	37	37
5.xi.27	5	8	14
6.xi.27	35	50	29
7.xi.27	22	32	46
8.xi.27	17	49	22
9.xi.27	17	21	7
10.xi.27	46	42	38
11.xi.27	37	63	26
12.xi.27	49	74	73
13.xi.27	9	10	12
14.ix.27	8	8	6
15.xi.27	4	10	13
16.xi.27	5	6	12
17.xi.27	1	1	1
18.xi.27	1	2	15
19.xi.27	80	51	121
20.xi.27	17	32	36
21.xi.27	—	4	6
22.xi.27	13	3	14
23.xi.27	5	4	12
24.xi.27	51	33	204
25.xi.27	58	36	182
26.xi.27	—	—	10
27.xi.27	—	—	5
28.xi.27	—	—	140
29.xi.27	—	—	5
30.xi.27	—	—	55
1.xii.27	—	—	28
2.xii.27	—	—	53
3.xii.27	—	—	58
5.xii.27	—	—	41
6.xii.27	—	—	89
8.xii.27	—	—	55
9.xii.27	—	—	47
10.xii.27	—	—	91
11.xii.27	—	—	90
12.xii.27	—	—	126
13.xii.27	—	—	44
14.xii.27	—	—	204
15.xii.27	12	—	48
16.xii.27	—	—	22
17.xii.27	—	—	8
18.xii.27	—	—	5
19.xii.27	—	—	6
20.xii.27	—	—	61
21.xii.27	—	—	238
22.xii.27	—	—	134
23.xii.27	—	—	111
24.xii.27	—	—	30
25.xii.27	—	—	32
26.xii.27	—	—	11
27.xii.27	—	—	92

Date.	Trypanosomes seen :		
	vivax	*brucei*	*congolense*
28.xii.27	—	6	162
29.xii.27	—	—	125
30.xii.27	—	—	141
31.xii.27	—	—	4
2.i.28	—	—	48
3.i.28	—	—	73
4.i.28	—	—	10
5.i.28	—	—	102
6.i.28	—	—	51
7.i.28	—	—	244
8.i.28	—	—	254
9.i.28	—	—	387
10.i.28	—	—	750

On 11.i.28 the animal was unable to rise and it died during the night. *Post-mortem* findings typical of trypanosomiasis. Here again *T. congolense* predominated throughout the disease.

Bull 100.

Inoculated on 8.iv.27 with 5cc. fresh blood of a goat infected with *T. congolense*. *T. congolense* appeared in the blood of the bull on 20.x.27. During this period the animal had been dipped regularly twice weekly, and the dipping was regularly continued. On 16.ii.28, when the animal ceased to be examined the condition was good. At the date of writing it appears in good health.

After the first appearance of *T. congolense* on 20.x.27, trypanosomes were not again seen in the 50 fields examined daily until 5.xii.27.

The subsequent findings were as follows :—

Date.	Trypanosomes seen :
	congolense
5.xii.27	3
9.xii.27	3
10.xii.27	56
11.xii.27	52
13.xii.27	10
14.xii.27	73
15.xii.27	30
16.xii.27	4
17.xii.27	4
18.xii.27	88
19.xii.27	2
21.xii.27	45
22.xii.27	40
25.xii.27	14
26.xii.27	5
27.xii.27	147
28.xii.27	22
4.i.28	79
8.i.28	5
10.i.28	5
11.i.28	50
12.i.28	35
16.i.28	10
22.i.28	15
1.ii.28	8
3.ii.28	10
4.ii.28	14
9.ii.28	5

Bull 108.

Healthy clean animal, had been dipped regularly twice weekly for many months.

On 17.xi.27, inoculated with 5 cc. fresh blood of Ox 117 (trivalent infection).

From 17.xi.27 was dipped three times weekly.

On 29.xi.27 *T. congolense* first seen in blood.

On 1.xii.27 *T. vivax* and *T. brucei* appeared. Died 11.xii.27 of typical trypanosomiasis.

The examination schedule is as follows :—

Date.	Trypanosomes seen :		
	vivax	*brucei*	*congolense*
29.xi.27	—	—	48
30.xi.27	—	—	25
1.xii.27	48	41	260
2.xii.27	5	—	211
3.xii.27	4	—	114
4.xii.27	—	—	47
5.xii.27	—	—	24
6.xii.27	8	—	44
8.xii.27	6	5	38
9.xii.27	—	—	26
10.xii.27	—	—	19
11.xii.27	—	5	20
12.xii.27	11	—	70
13.xii.27	—	—	6
14.xii.27	10	—	204
15.xii.27	—	—	27
16.xii.27	—	—	84
18.xii.27	—	—	25
19.xii.27	—	—	46
20.xii.27	—	—	21
21.xii.27	—	—	115
22.xii.27	—	—	77
23.xii.27	—	—	32
24.xii.27	—	—	10
25.xii.27	—	—	55
26.xii.27	—	—	9
27.xii.27	—	—	61
28.xii.27	5	—	53
29.xii.27	—	—	56
30.xii.27	—	—	65
31.xii.27	—	—	11
1.i.28	—	—	14
2.i.28	—	—	15
3.i.28	—	—	54
4.i.28	—	—	62
5.i.28	—	—	6
6.i.28	—	—	52
7.i.28	—	—	1,200
8.i.28	—	—	1,000
9.i.28	—	—	104
10.i.28	—	—	50

Bull 113.

Clean healthy animal ; on 17.xi.27 inoculated with 5 cc. fresh blood of Bull 117, subcutaneously. Had been dipped for months twice weekly ; from 17.xi.27 dipping was stopped.

On 26.xi.27, *T. congolense* first seen in blood.

On 27.xi.27, *T. vivax* and *T. brucei* seen.

On 6.ii.28 animal died and *post-mortem* findings were those of typical trypanosomiasis.

Examination findings as follows :—

Date.	Trypanosomes seen :		
	vivax	*brucei*	*congolense*
26.xi.27	—	—	5
27.xi.27	11	9	47
28.xi.27	—	—	51
29.xi.27	—	—	24
30.xi.27	21	—	105
1.xii.27	—	—	49
2.xii.27	—	—	5
3.xii.27	12	—	60
4.xii.27	—	—	9
5.xii.27	—	—	5
6.xii.27	—	—	5
7.xii.27	18	4	21
8.xii.27	—	—	99
9.xii.27	—	—	64
10.xii.27	—	—	70
11.xii.27	—	—	18
12.xii.27	—	—	138
13.xii.27	—	—	15
14.xii.27	—	—	87
16.xii.27	—	—	4
17.xii.27	—	—	3
18.xii.27	—	—	58
19.xii.27	—	—	34
20.xii.27	—	—	20
21.xii.27	—	—	112
22.xii.27	—	—	40
23.xii.27	—	—	20
24.xii.27	—	—	38
25.xii.27	—	—	25
26.xii.27	—	—	59
27.xii.27	—	—	55
28.xii.27	—	—	16
29.xii.27	—	—	20
30.xii.27	—	—	94
31.xii.27	—	—	26
2.i.28	—	—	11
3.i.28	—	—	30
4.i.28	—	—	23
5.i.28	—	—	101
6.i.28	—	—	51
7.i.28	—	—	28
8.i.28	—	—	40
9.i.28	—	—	19
10.i.28	—	—	100
11.i.28	—	—	5
12.i.28	—	—	5
13.i.28	—	—	10
14.i.28	—	—	200
15.i.28	—	—	50
16.i.28	—	—	15
17.i.28	—	—	35
18.i.28	—	—	1,000
19.i.28	—	—	80
20.i.28	—	—	30
21.i.28	—	—	100

Date.	Trypanosomes seen :		
	vivax	*brucei*	*congolense*
22.i.28	—	—	150
23.i.28	—	—	30
24.i.28	—	—	110
25.i.28	—	—	10
29.i.28	—	—	10
1.ii.28	—	—	20
2.ii.28	—	—	40
3 ii.28	—	—	20
4 ii.28	—	—	30

Of these animals, two, at the date of writing, are alive and apparently in good health. Both of these had been regularly dipped, though in the case of Bull 56 improvement actually became manifest after dipping had stopped.

Four animals died, two of which had been dipped, and two had not been dipped.

Obviously there is not much to be inferred from these experiments. Differences in individual resistance must be taken into account, and it is by no means certain that the two apparently recovered animals, Nos. 56 and 100, are free from danger.

On general grounds the employment of arsenicals to keep trypanosome infections in abeyance by direct drug action would seem to encourage the development of arsenic-fast strains. The *brucei* and *congolense* groups of trypanosomes are notoriously resistant to arsenic, so that it would be surprising if they responded to the quantities made available by dipping.

On the other hand, as has already been noted, judicious dipping leads to a general improvement in an animal's condition, and so will, presumably, give it the best possible chance of utilising its resources in the struggle against the parasite.

References.

Bevan, Ll. E. W. (1926). The Influence of Dipping in Solutions of Arsenic upon the Course of Trypanosomiasis.—Jl. Comp. Path. & Therap., xxxix, pt. 4, pp. 284–292.

Carpenter, G. D. H. (1913). Second Report on the Bionomics of *Glossina fuscipes* (*palpalis*) of Uganda.—Reports of S.S. Commission of R.S. no. xiv, pp. 1–37.

Cooper, W. F. & Laws, H. E. (1915). Some Observations on the Theory and Practice of Dipping.—Parasitology, viii, pt. 2, pp. 190–217.

Duke, H. L. (1912). Some Experiments with Arsenphenylglycin and *Trypanosoma gambiense* in *Glossina palpalis*.—Proc. R.S., B. xxxvi, pp. 19–31.

Duke, H. L. (1919). An Enquiry into the Relations of *Glossina morsitans* and Ungulate Game, with special reference to Rinderpest.—Bull. Ent. Res., x, pt. 1, pp. 7–20.

Green, H. H. & Dijkman, C. D. (1918). Some Experiments on the Fate of Arsenic in the Animal Body.—Rep. Dept. Agric. Union S. Africa., vii & viii, pp. 689–698.

Harris, R. H. (1923). Jl. Dept. Agric. Union S. Africa, Pretoria, vii, no. 1, pp. 11 and 20.

Harris, R. H. (1923). Op. cit., vii, no. 5, pp. 389–390.

Harris, R. H. (1925). Op. cit. xi, no. 4, pp. 289–290.

Newstead, R. (1924). Guide to the Study of Tsetse Flies. University Press of Liverpool.

Yorke, W. & Blacklock, B. (1915). Food of *Glossina palpalis* in the Cape Lighthouse Peninsular, Sierra Leone.—Ann. Trop. Med. & Parasit., ix, pp. 363–379.

A METHOD FOR THE REARING OF EGG PARASITES OF THE SUGAR-CANE MOTH-BORERS.

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(Plates I & II.)

In 1921, when engaged on work on the small moth-borers of sugar-cane (*Diatraea* spp.), the writer devised the method and apparatus for the rearing of the egg-parasites (*Trichogramma minutum*, Riley, and *Prophanurus alecto*, Cwfd.) of these insects which is described hereafter. It was proposed at the time to investigate further this method of control of small moth-borers, but owing to the change in the writer's position it has not been possible since to do any extensive work in this direction. As the rearing of *Trichogramma* by this method has been practised since 1921 on a small scale on the two estates on which it was initiated, and has now been adopted in a modified form on two other sugar estates in the Colony, it has been considered desirable to give an account of the method and a description of the appliances used in the rearing of these egg-parasites.

As to the commercial success of the method there is little information to go upon. This form of control has not been applied on a large enough scale to obtain conclusive results, but the number of parasites it is possible to rear even in a small way, and the low cost of doing this, has led to the belief that the method may be employed with considerable success if carried out on an extensive scale. It is hoped, at some future date, to institute trials on a large scale and thus to obtain sufficient data to draw definite conclusions.

The Status of the Parasites.

Of the sixteen parasites attacking small moth-borers in British Guiana the two egg-parasites, *Trichogramma minutum* and *Prophanurus alecto*, are without doubt under present conditions the most important enemies of *Diatraea* in the country. It has been found that as many as 75 per cent. of the eggs in a field of mature canes may be parasitised by *Trichogramma*, and the average parasitism by the insect must be in the vicinity of 40 per cent. of all eggs. Taken throughout the year *Prophanurus* is on the whole not nearly so important or so effective an enemy of small moth-borers, although at certain periods, particularly towards the end of the year, that is during the wet season, this insect exerts a decided check on the pest, and is in fact at such times its most important enemy.

The significance, therefore, of any method of increasing the numbers of these egg-parasites will be seen, and it was with this object in view that the writer undertook the rearing of *Trichogramma* in 1921.

Trichogramma minutum would appear to be well distributed in the sugar-growing countries of the Western Hemisphere and is known to occur in the United States, Central America, the West Indian Islands, and in British and Dutch Guiana. *Prophanurus*, on the contrary, has only been recorded from Porto Rico, Barbados, Trinidad, and British Guiana, and, therefore, cannot be considered of the same importance as *Trichogramma* as an enemy of small moth-borers.

It is significant also that other species of *Trichogramma*, namely *T. nanum* and *T. australicum*, are parasitic on species of *Diatraea* in Java and Mauritius, both species occurring in Java, and the latter only in Mauritius. It is possible, therefore, that the method of rearing *Trichogramma minutum* now described will be applicable also to these other species of *Trichogramma*.

With an egg-parasitism such as occurs in this country, quite apart from any other natural enemies, one might imagine that the damage done by small moth-borers would be of little importance. Unfortunately just the reverse is the case, and small moth-borers inflict damage to the extent of about 90 per cent. of the stalks and 25 per cent. of the joints of sugar-cane grown in British Guiana. The reason for this severe damage is not difficult to find. Many of the cultural methods in vogue are directly responsible for the prevalence of moth-borers in the canefields, and as these have been previously dealt with by the writer,* it will be sufficient merely to mention what measures of control have been advocated in this direction. These are, according to their importance : (1) the non-burning of fields prior to reaping ; (2) the treatment of seed-cane or " tops " by immersion in cold water for 72 hours ; (3) the disposal of discarded " tops " and other field refuse ; (4) the elimination of " false rows " or " old banks " in replanted fields ; (5) the " supplying " of fields with only " tops," so far as possible ; and (6) the reduction of ratooning to a minimum, for preference not beyond the second ratoons. If, in addition to the measures recommended above, serious efforts were made to conserve the parasites, both egg and larval, at present found in the cane-fields, as well as to increase their numbers by rearing, it is believed that within a few years the damage caused to sugar-cane by small moth-borers in this country could be reduced to a negligible, or at least a more acceptable, figure.

Method of Rearing and Appliances.

The first requisite of this method is an adequate supply of moth-borer eggs. Although a borer gang is regularly employed on many sugar estates in this Colony, amongst whose duties is the collection of egg-masses of *Diatraea,* it was not found possible to utilise the egg-masses thus obtained for the rearing of parasites. The reason for this is that the work of conserving such of these parasites as are present normally in the fields necessitates the keeping of all egg-masses collected by the gangs for four days after their collection in order to recognise the parasitised ones, which become black after such a period, by which time a large number of the unparasitised masses have either produced larvae, or are too far developed for the parasites to work upon them.

In order then to obtain a regular and adequate supply of moth-borer eggs, it is necessary to produce them under artificial conditions by confining moths in suitable cages for oviposition, and this is the system adopted in this work. In the ovipositing cages supplies of either green or dried sugar-cane leaves are provided, on which the moths lay their eggs. It is usually more convenient to use dry leaves, as no provision need be made for keeping them fresh. It is more difficult, however, to detect egg-masses on dry leaves, but the necessary skill in this direction is soon acquired by the assistants. The types of cages used for confining the moths for egg-laying, called herein Ovipositing Cages, will be described in detail later.

Similarly it has been found that the only satisfactory way of obtaining moths is to breed them, and for this purpose a regular supply of larvae is necessary.

Larvae obtained from the fields are left *in situ* in the shoots in which they are found. These shoots are stored in boxes, with a layer of damp sand on the bottom, and in them pupation takes place, the boxes themselves being placed in a suitable cage, called herein the Pupating Cage. It has been found that for the boxes old kerosene oil cases, 21 inches long by 10 inches broad and 14 inches high, are very suitable. In order to obtain pupae it is necessary to examine the shoots in these boxes from day to day. In practice it has been found that the shoots need not be examined for about fourteen days after they are collected, as this usually gives ample time before moths can emerge. Shoots that are found to contain pupae on these examinations are taken

* Cleare, L.D. " Notes on the small Moth-borers of Sugar-cane in British Guiana." Bull. Ent. Res., xiii, 1922, pp. 457–468.

from the boxes and the pupae removed. Those shoots still containing larvae are transferred to another box to be re-examined a few days later. Pupae thus obtained are placed in trays in the bottom of the ovipositing cages, in which there is a layer of damp sand, for the emergence of the moths, or kept in a separate cage and the moths on emergence transferred to the ovipositing cages. If pupae are placed directly in the ovipositing cages care must be taken to ensure that the adults emerging therefrom are about equal in numbers as regards sex. This can be much more easily done by transferring the moths to a separate cage.

Having thus obtained larvae and pupae from which moths subsequently emerge and oviposit, it is necessary to consider the means employed for obtaining parasitised egg-masses.

Daily examinations are made of the ovipositing cages and all egg-masses laid during the previous night are collected. In doing this the egg-masses are removed with a piece of the leaf on which they are deposited about 2 or 2½ inches in length, care being taken to have the egg-masses in as central a position as possible. With green leaves this is more important than with the dry ones, as the former curl rapidly and closely, and in the subsequent uncurling and placing in the Parasitising Box those with the egg-masses well placed are less liable to injury.

The Ovipositing Cages.

Two types of cages have been used, each with its own advantages.

TYPE I (Pl. i, fig. 1). This is a rectangular wooden cage, the outside dimensions of which are 19½ inches by 18 inches by 2 feet 1½ inches high (text-fig.1). It consists of four frames, 18 by 24 inches, constructed of ¾ by 1½ inch wood, and covered with mosquito wire-mesh, held in place by flat wooden moulds, ¼ inch thick by ½ inch wide.

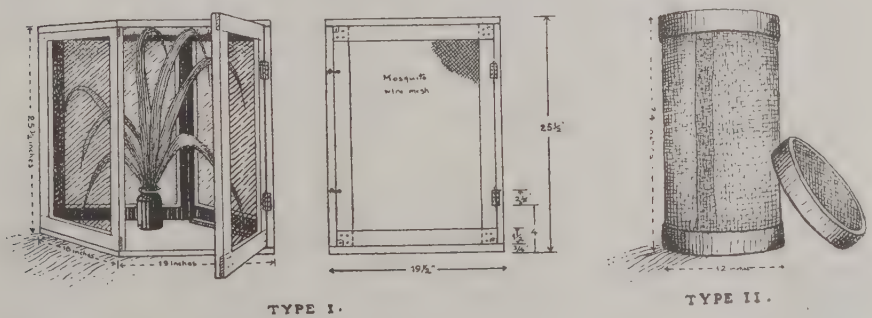

Fig. 1. Ovipositing cages.

The top and bottom of the cage are of solid wood, ¾ inch thick. The whole cage is kept together by small brass hooks 1½ inches long, four hooks or eyes to a side, the hooks on one side attaching to eyes on the adjacent side, thus holding the cage together. These hooks and eyes work on three sides of the cage, the fourth side being the door, which is attached by hinges on one side, two hooks on the other side serving to keep the door closed tightly. The top and bottom are attached to the sides by three similar hooks, one to each side, the door being left free. The door side of the cage is

19½ inches, opening to the width of eighteen inches, and the hinges should be of a simple loose pin type, so that the door can be removed easily and the whole cage taken down. The cage is drawn so closely together by the hooks that it is impossible for the insects to escape, and their use greatly facilitates construction. The top and bottom of the cage measure 19½ by 18 inches each, fitting outside, and are held together by two transverse strips of wood 16½ inches long, 1 inch wide and ¾ inch thick, nailed inside. These strips of wood are nailed ¾ inch away from the edges along the shorter sides and serve as braces for the entire cage, besides preventing any lateral movement of the top or bottom. The cages are painted white to facilitate cleaning and are placed on a stand of a convenient height, the legs of which are protected against ants (Pl. ii, fig. 2).

While the above type of cage has many advantages, including the ease with which it may be examined and taken to pieces for cleaning and storage, it has also a few decided disadvantages, perhaps the most important of which is the fact that the moths oviposit somewhat freely on the wood-work frames of the sides and door. Such egg-masses cannot be used for parasitism, in fact it is necessary to destroy them daily during the collection of the egg-masses from the leaves.

Type II (text-fig. 1). This type of cage is virtually a cylinder of mosquito wire-mesh, with a top and bottom of shallow galvanized iron pans which fit over the ends of the cylinder. The top pan has the greater portion of its flat surface removed and replaced by mosquito wire-mesh soldered into place. If the cylinder is not less than 12 inches in diameter the difficulty of examining is considerably reduced, and the height of the cage should be about 2 feet. In making the cylinder the ends of the wire should overlap about 3 inches and should be held together either by small brass paper-fasteners of the split-pin type or laced with a strand of the same wire. These cages are placed on a table suitably protected against ants.

In this type of cage it will be found most convenient to use dry leaves for the moths to oviposit upon, as this avoids the necessity of any receptable containing water being placed in the cage. The advantage offered by this cage is that the majority of the egg-masses are deposited on the leaves, for the moths will not oviposit on the wire mesh. There is an additional advantage in the cost, which is very much less than that of the previous type, as only the top and bottom pans need be made by skilled labour.

Pupating Cage.

This is a large cage measuring 10 feet long, 5 feet high and 2 feet 6 inches wide, over-all measurements (Pl. i, fig. 2). The cage may be described best as a double shelf enclosed by doors. Two shelves are supported on four frames 4 feet 11 inches high and 2 feet wide, the uprights being of spruce scantling (2 inches square) held together by three strips of wood 2 inches by ⅞ inch, the strips of wood being let into the uprights, one at the top, a second one 25 inches from the top, and the third one 49 inches from the top, these strips of wood forming supports for the shelves. To the second and third of these supports the shelves are nailed, the lower one projecting two inches beyond the slides, the shelves being of ⅞ inch board. The spaces between the uprights are closed by means of doors, the front and back each having three doors, each 3 feet wide, and the two end doors being 2 feet wide and 4 feet high (text-fig. 2).

The doors are made of a frame-work of ⅞ inch board, 2 inches wide, divided into two panels by a central horizontal strip 4 inches wide, the joints being rabbeted and nailed. The front doors are each hung on three hinges 1½ inches long, the three back and two side doors each being held in position by four hooks 1½ inch long. The doors are covered with thin muslin or other cheap material, which is attached inside by wooden moulds ¾ inch by ¼ inch thick. The legs of the cage must be protected against ants.

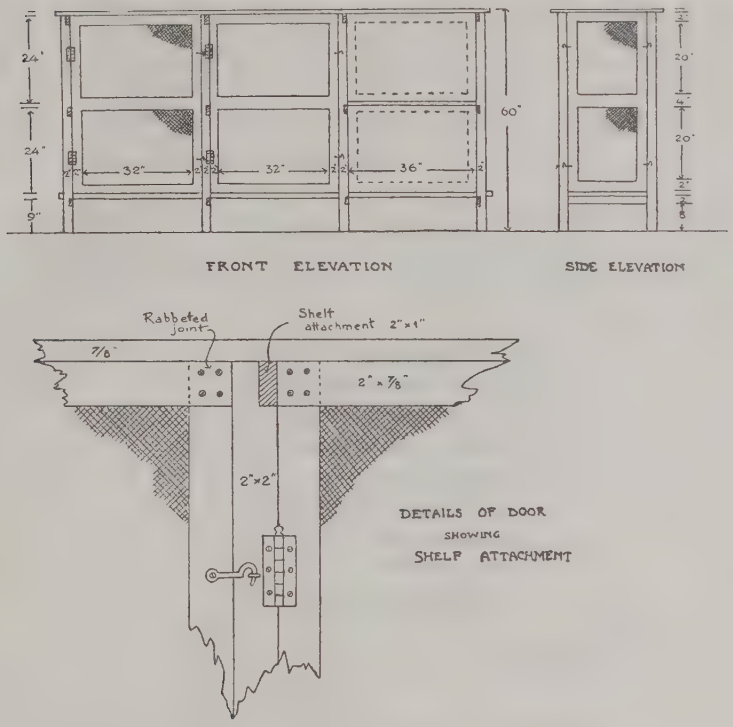

Fig. 2. Details for the construction of the pupating cage.

In this cage the boxes containing the shoots with larvae are stored until pupation occurs. A cage of the dimensions given above will hold twenty boxes of shoots of the size given previously. One such cage of twenty boxes should keep ten ovipositing cages supplied with moths.

Parasite Rearing Box.

This is a glass-topped box, made of wood, 22 inches square and 4 inches deep, outside measurements, divided into a base of $2\frac{1}{2}$ inches and a cover of $1\frac{1}{2}$ inches (Pl. i, fig. 3). Three-quarters of an inch spruce is used in the construction of the cover, sides, and bottom. An extra piece $\frac{1}{4}$ inch thick is fitted inside the base, projecting $\frac{1}{2}$ inch above the sides to prevent lateral movement of the cover. Cover of the box to be mitred or dovetailed. The glass (21 inches square) is fitted into $\frac{1}{8}$ inch wide grooves made in the sides of the cover, 1 inch space below and $\frac{3}{8}$ inch space above groove. One side of the cover is removable by screws for replacement of the glass. Covering the entire bottom of the box is a sheet of asbestos mill-board, or other absorbent material, $\frac{1}{4}$ inch in thickness, the bottom of both the asbestos and box being painted. Should a material other than asbestos be used, care should be taken to avoid any of which the fibres are loose and long, as such fibres would in all probability hinder the movement of the parasites about the box. Across the bottom of the box nine bands of wood or metal are fixed being equally spaced $1\frac{3}{8}$ inches apart (text-fig. 3) These bands should be $19\frac{1}{2}$ inches long by 1 inch wide, and, if of wood $\frac{1}{4}$ inch thick, of iron $\frac{1}{16}$ inch thick, or of brass $\frac{1}{8}$ inch thick, and have three holes in them, one at each end and a third in

the middle They are held in position by $\frac{1}{4}$ inch bolt-screws and nuts $1\frac{1}{2}$ inches long running through the bottom of the box as well as the asbestos, the heads of the bolts being countersunk in the bottom of the box from the outside; the nuts for these bolts should be of the " butterfly " or winged pattern (" thumb screws ") Along one side of the box eight 1-inch holes are bored, opening into the spaces between the bands, and fitted to these holes are glass tubes for the insertion of the parasites. The box should be painted white, and the bolts should be of brass or other non-rusting metal.

In these boxes parasitism of the egg-masses obtained from the ovipositing cages takes place. The egg-masses, as previously mentioned, are removed with a piece of the leaf on which they have been deposited measuring about 2 inches long, and are arranged in rows in these boxes along the spaces between the metal bands, the ends

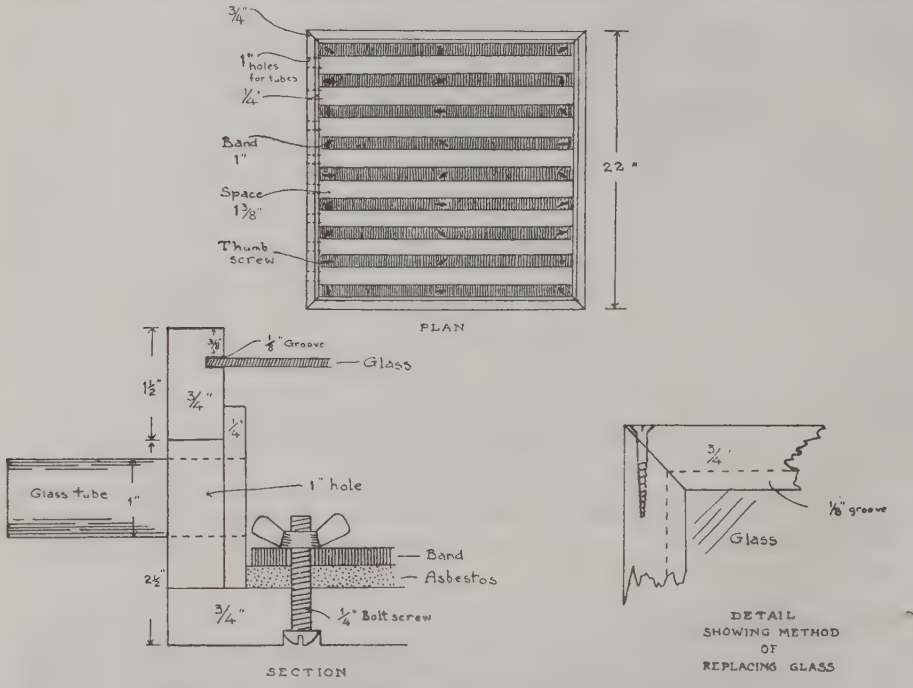

Fig. 3. Details for the construction of the parasite rearing box.

projecting a short distance under the bands, which on being screwed up keep the pieces of leaf securely in place. If green leaves are used it will be necessary first to damp the asbestos mill-board, or other absorbent material used in the bottom, to prevent excessive drying of the leaves and subsequent curling, but care must be taken to avoid overdoing this and thus creating an excess of moisture, which will condense on the glass top of the box The parasites are admitted to the box by means of the glass tubes placed in the holes bored along the sides, and can soon be observed at work on the egg-masses.

Parasite Room.

In September 1922, after the writer's assumption of other duties, Mr. H. E. Box took over the insect control work on the estates. No change was made in the method

of rearing the parasite or in the manner of obtaining material for this purpose, but a special room was constructed for the storing of the pupating cages containing shoots, on the principle of the darkened box and glass tube ; but in this instance the box assumed the dimensions of a room and was protected against the invasion of ants, and in place of a glass tube there was a wire-meshed rectangular trap (Pl. ii, fig. 1).

The entire room measures 12 feet 4 inches by 8 feet 4 inches by 8 feet 6 inches, and is raised off the ground on concrete pillars, 1 foot 2 inches by 9 inches square, standing in concrete basins which are filled with crude petroleum to keep off ants. Around the entire room is a ventilation space at floor level 7 inches wide, screened wtih mosquito wire-mesh and protected on the outside by a sloping board, and similarly at the top of the sides there is a screened space of 2 inches, but here the eaves of the roof form the protection. There is a double door, one being of wire-mesh, the other of wood, and along each side, four feet from the floor, is a window, 1 foot 11 inches by 2 feet 3 inches, screened with wire-mesh and fitted with blinds of black Italian cloth, each protected from the weather by a lean-to measuring 2 feet 4 inches by 3 feet. When the blinds are dropped and the wooden door closed the only light entering the room is from the light trap. The trap itself is of perfectly simple construction, rectangular, measuring 2 feet by 1 foot by 1 foot, and a double sliding door is fitted to this which can be inserted when it is necessary to remove the trap with the contained parasites or to close the orifice when the trap is not in place. The trap is protected from the weather by an extension of the gabled roof for 3 feet 6 inches beyond that end of the building. The roof is covered with corrugated galvanised iron sheets. The accompanying photograph will show most of the details of the room.

In large scale operations such a room would be of great convenience and highly desirable. It would then be necessary to store only the boxes containing shoots on racks in the room, pupating cages being entirely eliminated. If the work is being carried out on a small scale, however, it would be more economical to arrange some such trap directly on the pupating cages.

The Method in Use.

Although no large scale trial of the method has been undertaken, it has been in use in a small way for a sufficient time to allow of certain figures being accumulated, and these would appear to be of sufficient interest to include here.

For the first six months of operating on one estate, with only 10 ovipositing cages and a similar number of parasite rearing boxes, the following results were obtained :—

	Egg-masses for parasitism.	Parasitised Egg-masses obtained.	Parasites used
January	971	675	660
February	1,261	868	980
March	1,687	1,385	1,605
April	1,204	950	1,170
May	1,345	1,040	1,245
June	1,665	1,038	1,350
July	4,996	3,471	4,160
	13,129	9,427	11,170

From a total of 13,129 egg-masses which were placed in the rearing boxes for parasitism, 9,427 parasitised masses were obtained, or 71·6 per cent., and to effect this some 11,170 parasites were used. Taking an egg-mass as containing an average

of 35 eggs and 2·5 parasites as emerging from each parasitised egg, the total number of parasites obtained from the 9,407 parasitised clusters would be 823,112, or 73·6 times the number of parasites used.

Similarly on another estate in five months 21,737 parasitised egg-masses were obtained by utilising 15,305 parasites. Calculated at the same rate as the previous example, this would represent 1,901,926 parasites, or 124·2 times the number of parasites used.

On another estate the number of parasitised clusters produced amounted to about 30,000 in three months, which at the rate given above would represent 2,625,000 parasites, or an average of 35,000 parasites per diem of 75 working days.

Acknowledgements.

In conclusion I wish to thank the Honourable W. M. B. Shields, Director of Messrs. S. Davson & Co. Ltd., Berbice, British Guiana, for giving permission to use certain of the figures appearing in this paper and to obtain the photographs of the original cages utilised in the work, which are still in use on the estates of that firm; and Mr. H. W. B. Moore, Entomologist to Messrs. Curtis Campbell & Co. Ltd., British Guiana, for supplying information on the working of the method on the estates on which he is engaged.

Fig. 1. Ovipositing cage. Type 1.

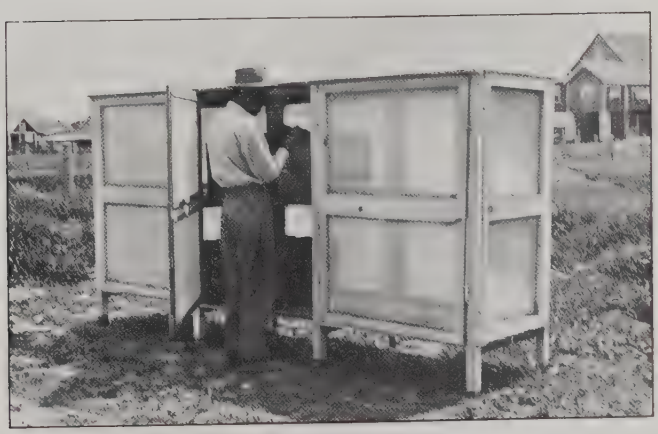

Fig. 2. Pupating cage.

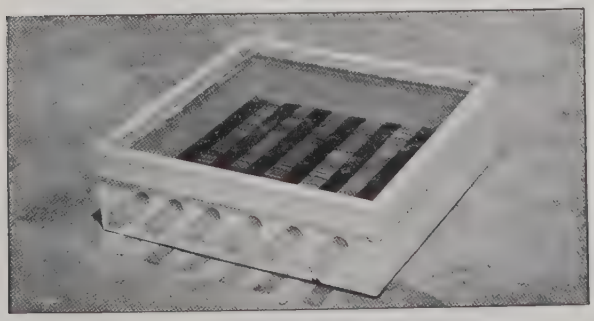

Fig. 3. Parasite rearing box.

Fig. 1. Parasite room erected by Mr. Box.

Fig. 2. Ovipositing cage showing details of stand.

NOTES ON THE PROCESS OF DIGESTION IN TSETSE-FLIES.

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1. Introduction.

The discovery of an anticoagulin in the salivary glands and a coagulin in the mesenteron of *Glossina* caused us to make some observations on the process of digestion in these flies in order to discover the purpose of these bodies. The most important work on such enzymes in insects is a paper by Cornwall & Patton,[1] who examined the secretions of a number of blood-sucking insects and ticks in India in relation to the coagulation of blood. They found an anticoagulin to be present in the salivary glands of the following habitual or occasional blood-suckers: *Philaematomyia insignis* (*Musca crassirostris*), powerful; *Musca pattoni*, weak; *Tabanus albimedius*, powerful; *Anopheles subpictus* (*rossi*) and *A. fuliginosus* (*jamesi*), powerful; *Conorhinus rubrofasciatus*, powerful; *Argas persicus*, weak-powerful. They record that no anticoagulin was found in *Musca nebulo*, *M. convexifrons*, *Stomoxys* sp., *S. calcitrans* and *Cimex rotundatus*. They found a coagulin in the guts of the following: *P. insignis*, powerful; *M. convexifrons*, moderately powerful; *M. pattoni*, powerful; *S. calcitrans* and *S.* sp., both powerful; and none in the following: *M. nebulo*, *C. rotundatus* and *A. persicus*. Their suggestion that *P. insignis* possesses the anticoagulin because it is a surface feeder, scratching the skin of its host and drinking the exuding blood, while *Stomoxys* being a deep feeder, does not need one, seems inconsistent, since the mosquitos and *Tabanus* are also not surface feeders. They suggest no adequate reason for the presence of the coagulin.

In the following pages the nature of these enzymes in the tsetse-fly is discussed, and we have attempted to discover their uses by operative treatment of the fly and a study of the movements of the blood mass in the alimentary canal.

Our thanks are due to Mr. A. W. Taylor, Junior Entomologist to the Investigation, for his assistance in dissecting out the large amount of material required for the work *in vitro*.

2. Anatomy of the Alimentary Tract.

Fig. 1 is a diagram of the alimentary tract of the tsetse-fly. The mouth-parts consist of a labrum and labium, which together form a tube enclosing the hypopharynx, and the three elements constitute the proboscis. The lumen of the proboscis continues backwards into a small thin-walled pharynx followed by a narrow oesophagus, which passes into the proventriculus. From this a dorsal duct continues and widens out into the fusiform mesenteron, or midgut, and another duct leaves the proventriculus ventrally and passes to the sac-like crop, which lies below the midgut, has membranous walls and contains gas. A double band of cells of a special nature in the anterior part of the mesenteron form a gland of unknown

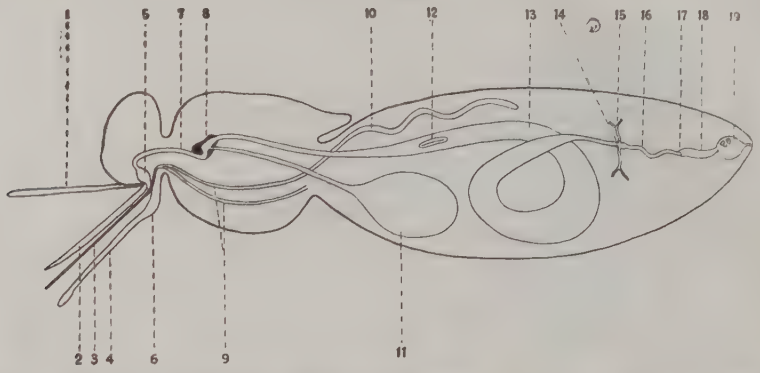

Fig. 1. Diagram of alimentary system of a tsetse-fly: 1, palp; 2, labrum; 3, hypopharynx; 4, labium; 5, pharynx; 6, bulb of proboscis; 7, oesophagus; 8, proventriculus; 9, salivary ducts; 10, salivary gland; 11, crop; 12, mesenteric gland; 13, mesenteron; 14, sphincter mesenteri; 15, Malpighian tubes (cut short); 16, prorectum; 17, valva prorecti; 18, mesorectum; 19, metarectum.

function. The mesenteron is of moderate length, having one more main coil than the diagram shows. Towards its posterior end it narrows abruptly with an increased development of circular muscle fibres, and this narrow portion ends in a powerful sphincter (fig. 2). This sphincter almost corresponds to the anus of vertebrates in that only faeces pass it, and the names ileum, colon and rectum, which are applied in insect terminology to the regions of the hindgut are very unsatisfactory. The first portion, for which we propose the name "prorectum," is a narrow powerful tube, the pores of the Malpighian tubes entering it at a small

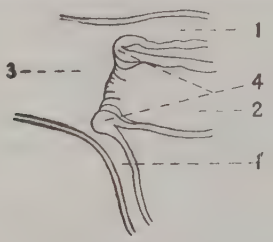

Fig. 2. Sphincter mesenteri of *G. morsitans* shown in optical section: 1, lumen of Malpighian ducts; 2, lumen of mesenteron; 3, lumen of prorectum; 4, sphincter, half relaxed.

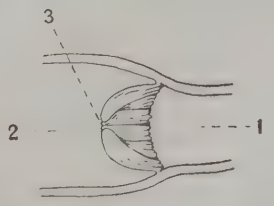

Fig. 3. Valva prorecti of *G. morsitans* shown in optical section: 1, lumen of prorectum; 2, lumen of mesorectum; 3, valve, slightly open.

dilatation immediately behind the sphincter mesenteri. At its hinder end is a simple valve formed by a reflection of the gut wall inwards and backwards to form a nipple-like projection, which protrudes into the next region, called here the "mesorectum" (fig. 3). This region is formed by a sausage-shaped distensible tube, which communicates with the globular "metarectum" by a small pore situated on the antero-dorsal wall of the latter. In the wall of the metarectum are the usual four rectal papillae of the Diptera. It communicates with the exterior by a short canal.

The paired salivary glands lie dorsally, just below the body wall, and their ducts running forward into the head join closely behind the base of the hypopharynx, the lumen of which is a continuation of their common duct. The size of the salivary glands in tsetse-flies is not in proportion to the size of the different species. Thus, by weighing 100 dried glands of male *G. tachinoides* the weight of one gland was found to be 0·014 mg., and the weight of one dried gland of the much larger male *G. morsitans* was by the same method found to be only 0·009 mg. Again the volume of the glands was found approximately by drawing them with the aid of an Abbé drawing apparatus, and the average volume of one gland, five being drawn in each case, was as follows :—

G. tachinoides male...	0·031 c.mm.	*G. morsitans* male...	0·017 c.mm.
G. tachinoides female	0·038 c.mm.	*G. morsitans* female	0·036 c.mm.

This point is of importance in connection with the work *in vitro*, as it accounts for an apparent difference in the potency of the salivary enzyme in the two species.

3. Method of Feeding.

The mode of feeding as seen by the naked eye has been described by several workers. Resting on the skin the fly suddenly braces itself, spreading its legs a little. The palps stick straight out while the proboscis is lowered at right angles and introduced into the skin. If blood is not obtained quickly the fly pushes its proboscis in up to the bulb and moves it up and down, lacerating the tissues. If this does not cause a flow of blood the fly moves a little way on the skin and tries again till a satisfactory source of blood is found. It then feeds with about one-third of its proboscis inserted. Observation with a lens on a fly accustomed to captivity shows the stream of blood passing up the proboscis, and the rapid pumping of the pharynx is reflected at the soft skin at the base of the proboscis. At first the fly distends very slowly, but after a short time distension becomes exceedingly rapid, and in a matter of seconds the abdomen swells up to a relatively enormous size. The reproductions of photographs in Newstead's "Guide to the Study of Tsetse-Flies" show the distended condition very well.[2] While the fly is still feeding it often excretes a drop or two of grey or dark faeces and sometimes some clear fluid.

According to Austen & Hegh,[3] Rodhain and his colleagues, using citrated blood and feeding the flies through rat skin, found that the average meal of *G. morsitans* varied from 0·056 to 0·06 cc., with an occasional fly taking as much as 0·091 cc. Macfie,[4] working with *G. palpalis*, found that a female could imbibe 1·6 times her body weight of blood and a male 1·3 times the body weight. The figures obtained by us by weighing the flies before and after normal meals are as follows, average of five in each case :—

G. tachinoides	male 0·030 gm.	(220 per cent. of body weight).
	female 0·028 gm.	(140 per cent. of body weight).
G. morsitans	male 0·034 gm.	(140 per cent. of body weight).
	female 0·037 gm.	(160 per cent. of body weight).

After a meal the fly thus weighs about 2·5 times as much as before, and its heavy flight when so gorged exposes it to predacious enemies. The mechanism of draining the meal by which this dangerous period is shortened is dealt with below.

4. Enzymes influencing the Coagulation of Blood.

1. *Proof of their Presence.*

After dissection the material to be examined was placed in as small a volume of 0·5 per cent. saline as was convenient for manipulation. The requisite number of glands or mesentera having been collected, they were carefully teased up with needles and left overnight for the water to evaporate off. The salt prevented complete drying, so that next day the watchglass contained a slightly sticky mass. This could be easily rubbed up with a glass rod, and on adding a measured quantity of saline a homogeneous emulsion was obtained. The loss of activity caused by one day's drying was sufficiently small to be negligible, the resultant emulsion being considerably more potent than any obtained by treating the fresh material, which is not so readily emulsified.

For the comparison of results standard tests were chosen, which consisted, in the case of the salivary enzyme, in the addition of 25 glands emulsified in 0·2 cc. of saline to 1 cc. of blood. In order to employ a comparable standard test with the mesentera, 12½ of these organs were used emulsified in 0·2 cc. of saline. The bloods used were from (*a*) sheep, obtained by piercing the external jugular vein with a hypodermic needle (Record no. 10) and running off the required amount drop by drop; (*b*) fowl; (*c*) toad, *Bufo regularis*; (*d*) monitor lizard, *Varanus exanthematicus*; the blood being obtained in the last three cases by cutting the animal's throat. The tests were carried out in small test-tubes, 0·75 cm. in diameter, which were continuously agitated till clotting occurred in brief tests, or at regular intervals when coagulation was long delayed, and the end point of each test was taken as the moment when the blood became so solid that no flowing movement was perceptible. As the enzymes present in the fly would have to act at its natural temperature, all tests were carried out at room temperature. This varied little at the season when this work was done, and the tests were usually made at a temperature of 80–85° F.

The salivary glands of both *G. tachinoides* and *G. morsitans* were found to contain a powerful anticoagulin, as the figures in Table I show.

Table I.

Showing the Delay in the Coagulation of various Bloods caused by the Addition of an Emulsion of Salivary Glands of Glossina.

	Time of Coagulation.							
	Sheep.		Fowl.		Toad.		Lizard.	
	Mins.	Secs.	Mins.	Secs.	Mins.	Secs.	Mins.	Secs.
G. tachinoides—								
Normal time*	4	50	0	25	0	55	6	30
Time with 1 cc. of blood +25 glands	65	0	5	50	7	0	63	0
G. morsitans—								
Normal time	4	50	0	25	0	30	7	10
Time with 1 cc. of blood + 25 glands... ...	40	0	3	50	3	30	39	0

* The normal coagulation time of the blood of different individuals of a species may vary considerably.

There is no evidence that the salivary enzyme has any special degree of activity for any particular blood. It is considered that the apparent greater potency of *tachinoides* gland emulsion as opposed to that of *morsitans* is easily explainable by the

fact that the glands of the former are larger than those of the latter fly.* Cornwall & Patton[1] found that with *Philaematomyia insignis* the anticoagulin from the glands of the male fly was weaker than that of the female. Similar sex differences in the activity of the emulsions from *Glossina* could be demonstrated, but were probably only due to the greater size of the female glands.

The mesentera of both species of tsetse contain a powerful coagulin. The bloods of the sheep and monitor only were used to demonstrate this, as those of the fowl and toad clot too rapidly normally to be of much use in showing an accelerated coagulation rate. The record is given in Table II.

TABLE II.

Showing the Acceleration in Coagulation of various Bloods caused by the Addition of an Emulsion of Mesentera of Glossina.

	Time of Coagulation.			
	Sheep.		Lizard.	
	Mins.	Secs.	Mins.	Secs.
G. tachinoides—				
Normal time	4	50	7	10
Time with 1 cc. of blood +12·5 mesentera	0	55	1	45
G. morsitans—				
Normal time	2	50	6	30
Time with 1 cc. of blood +12·5 mesentera	0	45	1	15

The figures in Table II were obtained by using the entire mesenteron ; but when these organs were divided into three approximately equal parts, it was found that the anterior third was actively anticoagulant, and only the middle and posterior thirds contained the coagulant enzyme. These latter were in fact separately more actively coagulant than the whole mesenteron, since the inclusion of the anterior part neutralised some of the coagulant enzyme. The difference is well shown by the figures in Table III, which were obtained by testing the potency of the three portions of twenty mesentera against sheep's blood.

TABLE III.

Showing that the Coagulant Enzyme in the Mesenteron of Glossina *is confined to the posterior two-thirds of the Organ, the anterior Part having an Anticoagulant Enzyme.*

	Time of Coagulation.			
	G. morsitans.		*G. tachinoides.*	
	Mins.	Secs.	Mins.	Secs.
Normal time	3	40	4	10
1 cc. of blood +20 anterior thirds of mesenteron	43	0	79	0
1 cc. of blood +20 middle thirds of mesenteron	0	30	0	15
1 cc. of blood +20 posterior thirds of mesenteron	0	25	0	20

* The gland of a female *morsitans* is about the same size as that of a female *tachinoides*, but in a random collection of flies female *morsitans* are relatively scarce, perhaps 5 per cent., whereas the sexes of the other species are approximately equal in such a collection. The sizes of the glands are given on p. 41.

That the anticoagulin contained in the anterior portion is not secreted there but is derived from an overflow of the salivary glands was proved by the following experiment. Ten *G. tachinoides* had their salivary glands removed by the method described below (page 50) and were immediately given a full meal of human blood to wash out the anterior parts of the alimentary tract. Next day their midguts were dissected out and divided into the three portions as before. The coagulant property of the two hinder parts of the mesenteron remained unchanged, but the coagulation of 0·5 cc. of sheep's blood (normal time of clotting 3 mins. 45 secs.) was retarded by only 4 mins. by the addition of the anterior thirds of the mesentera of the ten flies. Thus the greater part of the anticoagulin had disappeared, and that a little remained was no doubt due to the fact that some of these pieces of mesenteron still contained blood, so that the washing-out process was not quite complete. This proves that the anterior part of the mesenteron secretes neither coagulin nor anticoagulin, but that its anticoagulant power is derived from the salivary glands.

In a similar way it was possible to prove the presence of an anticoagulin in the proventriculus of normal flies, also derived from the salivary glands and disappearing after the removal of these organs. Thus the coagulation time of 1 cc. of sheep's blood (normal time 3 mins. 40 secs.) was retarded to 26 mins. by the addition of an emulsion of 20 proventriculi from normal flies ; but when an emulsion of 10 proventriculi taken from the flies deprived of their salivary glands was added to 0·5 cc. of blood, the coagulation took place normally in 3 mins. 45 secs.

2. *Properties of the Enzymes.*

The secretion of the salivary glands, as it is seen when a gland is ruptured or when a small drop is expressed from the proboscis by pressure on the head of the fly, is a limpid and colourless fluid. Cornwall & Patton,[1] working with *Philaematomyia*, found that both the salivary gland and its secretion turned black an hour or so after dissection. With *G. morsitans* and *tachinoides* no such colour change takes place, even after several days' exposure to the air. No marked colour change takes place with the mesentera after dissection, though a considerable change in consistency occurs. After several hours the whole mass of mesentera in a watchglass becomes converted into a mucilaginous mass. This is probably due partly to bacterial action, the gut of the living fly being usually infected with bacteria, and partly to autodigestion of the tissues of the gut by the digestive ferments.

The anticoagulant and coagulant enzymes are non-dialysable and so are of a colloid nature. They are both readily soluble in water, dilute salt solution and dilute alcohol, the filtrates being practically as potent as the original emulsions. They are completely insoluble in ether, absolute alcohol and half-saturated ammonium sulphate. There is no evidence that treatment with these substances produces any diminution of potency in the dried emulsions. Using neutral red as an indicator the pH of a salivary emulsion was found to be approxiately 7·5, a figure which is just on the alkaline side of neutrality and is about the same as that of normal blood. An emulsion of mesentera gave a pH of approximately 6·5, which is just on the acid side of neutrality.

It was found that whereas the activity of both salivary and gut emulsions is only partly diminished by prolonged drying, the enzymes are rapidly destroyed in aqueous solutions. With sheep's blood, the ordinary coagulation time of which was 3 mins. 50 secs., a freshly prepared emulsion of *tachinoides* salivary glands gave a coagulation time of 57 mins. A similar emulsion 12 hours old gave a coagulation time of 27 mins., and with one 24 hours old the coagulation time was 4 mins. The power of the salivary enzyme is thus completely destroyed in aqueous solution in 24 hours, and the coagulant enzyme of the mesenteron in water loses its power even more quickly. This destruction of the enzymes was found to be due to bacterial action, for the addition of some simple bactericide, such as arsenious acid, which has no

appreciable effect on normal clotting, will prevent any such loss of potency. Sterilisation of the emulsions for ¾ hour at 60° C. had a rather similar preservative effect. One result of this bacterial destruction of the enzymes is that, however large a quantity of salivary emulsion is added to blood, clotting invariably takes place in 24 hours under ordinary experimental conditions. In one test a concentration equivalent to 300 glands in 1 cc. of sheep's blood was used, but clotting took place in 13½ hours. If, however, a little arsenious acid is added, the coagulation time becomes infinity with much lower concentrations of salivary enzyme.

An emulsion of 25 *tachinoides* glands was made in 0·1 cc. of normal KOH, and after an interval of 10 mins. the alkali was neutralised with 0·1 cc. of normal HCl. When the activity of the treated emulsion was compared with a control of 25 glands emulsified in normal KCl it was found to be slightly diminished. When the glands were treated with the acid first and then neutralised with the alkali, there was no loss of activity. Repetition of these experiments with *morsitans* mesentera showed that the gut coagulin was almost entirely destroyed when the alkali was applied first and lost about half its activity when the acid was used first.

The anticoagulant enzyme is more thermostable than the coagulant enzyme. The former is not much affected by temperatures below 90° C. At that temperature it is to a great extent inactivated in 15 mins. and completely destroyed in 30 mins. Rapid heating of a small quantity of the salivary emulsion to 100° C. followed by cooling by plunging the tube into cold water has little effect on the enzyme, though 100° C. for 15 mins. destroys it completely.*

The coagulant enzyme of the gut is to a great extent inactivated by exposure to 80° C. for 15 mins., and at 90° C. it is completely destroyed in a few minutes. As the fore part of the mesenteron contains a quantity of anticoagulin derived from the salivary glands, it might be expected that a timed exposure of an emulsion of whole guts to 80° C. would give a complete destruction of the coagulin, leaving the anticoagulin unchanged, so that the resulting solution, containing only the latter, would have a definitely retarding effect on coagulation. This, however, does not take place, normal clotting being obtained when an emulsion of whole mesentera so treated is added to blood. From this it is evident that when on emulsification the salivary secretion in the fore part of the mesenteron is intimately mixed with the coagulin of the hinder part, the two enzymes must combine in some way to form an inactive combination, while the excess of coagulin remains. Moreover this combination must be of such a nature that destruction by heat of the combined coagulin involves also the destruction of the anticoagulin, so that the latter is not liberated. It seems probable that this union is a form of weak chemical action rather than a process of adsorption.

It has thus been shown that these two active substances have all the ordinary properties of enzymes, the anticoagulin of the salivary glands being a rather more stable substance than the coagulin of the mesenteron.

3. *Theory of the Nature of the Enzymes.*

In order to determine the relationship between the concentration of the salivary enzyme and the coagulation time of blood, varying amounts of a salivary gland emulsion were added to a constant quantity of sheep's blood. The emulsion was prepared by the addition of 0·6 cc. of saline to 300 glands of *G. morsitans* and was divided into volumes representing an increasing number of glands. In each case the volume of fluid was made up to exactly 0·2 cc. by the further addition of the requisite quantity of saline. To ensure as exact a degree of accuracy as possible all

* Cornwall & Patton found that heating the salivary gland emulsion of *P. insignis* at 100° C. for 10 mins. does not destroy the anticoagulin, though it may reduce its activity.

measurements were made with the aid of the Agla Micrometer Syringe Apparatus. The addition of 1 cc. of blood to each tube of emulsion gave strictly comparable results, which are shown in Table IV.

TABLE IV.

Showing the Relationship between the Concentration of Salivary Enzyme and the Time of Coagulation of Sheep's Blood.

Number of Salivary Glands in Emulsion.	Time of Coagulation.		
	Hours.	Minutes.	Seconds.
0 (Control)	—	3	55
5	—	5	5
10	—	7	20
15	—	11	45
20	—	19	30
30	—	55	—
50	3	9	—
70	6	30	—
100	12–18	—	—

The figures in the earlier part of the series were plotted to give Diagram 1, the form of the curve resembling that which would be obtained by a proportionate diminution in the concentration of the fibrin ferment in blood. This indicates that, with the smaller concentrations at any rate, a given quantity of salivary enzyme will neutralise a proportionate amount of one of the substances involved in normal clotting. The destruction of the enzyme by bacterial action in the higher concentrations of the emulsion reduces the value of the results obtained with these.

An equivalent experiment could not be carried out with the coagulant enzyme of the gut, because the interval of time between normal and instantaneous clotting is too brief for an accurate series of subdivisions. For this reason when the varying amount

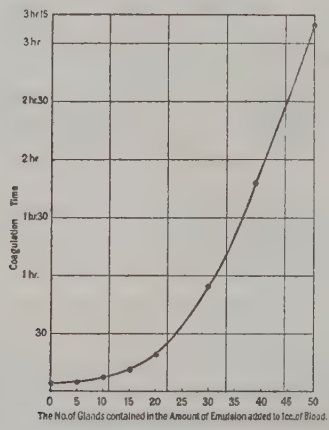
3 hr 15
3 hr
2 hr 30
2 hr
1 hr 30
1 hr.
30
Coagulation Time
0 5 10 15 20 25 30 35 40 45 50
The No. of Glands contained in the Amount of Emulsion added to 1cc. of Blood.

Diagram 1.

of gut emulsion was added to the blood a constant quantity of salivary emulsion was added with it in order to prolong the time of the reaction. As before, the volumes of the emulsions were measured by the Agla Micrometer Apparatus, the total

volumes being kept constant. Glands and midguts obtained from *G. tachinoides* were used in this series, and the results are shown in Table V.

TABLE V.

Showing the Effect on the Coagulation Time of Blood of a Mixture containing a varying Quantity of Coagulant Enzyme of the Mesenteron and a constant Quantity of Salivary Enzyme.

Number of Salivary Glands.	Number of Mesentera.	Time of Coagulation.	
		Minutes.	Seconds.
0 (Control)	0	2	50
25	0 (Control)	28	—
25	1	7	30
25	2	3	15
25	3	2	20
25	5	2	0
25	7·5	1	45
25	10	1	30

These figures show that the coagulant enzyme of the gut is considerably more potent, or present in larger quantity in the fly, than the anticoagulant enzyme of the salivary glands, the activity of 25 glands being neutralised by 2—3 mesentera. Diagram 2 shows the curve obtained by plotting the coagulation time against the number of mesentera contained in the mixed emulsion added to the blood. It will be seen that this curve may be divided into two parts by the dotted line representing the normal clotting time of the blood employed. The upper portion represents the activity of the diminishing excess of salivary enzyme, and the lower part represents that of the increasing excess of gut enzyme. In this way the form of the curve affords

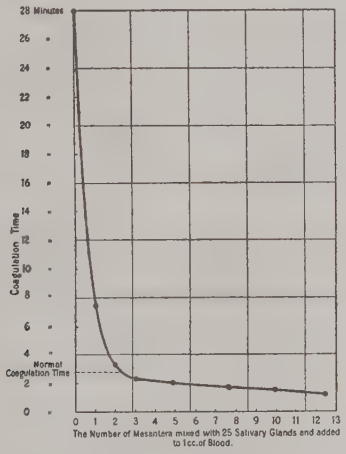

Diagram 2.

further evidence that when the anticoagulin and the coagulin are mixed they react together in some way to form an inactive compound and so neutralise each other. If this were not the case, a more graded form of curve would be obtained.

It was found, however, that when the salivary enzyme was allowed to act on the blood first and the gut enzyme was added after an interval of one minute, there was a substantial lengthening of the coagulation time compared with that which obtains

when the emulsions are mixed before being added to the blood. This is of course the sequence in which the enzymes come into contact with each other in the living fly. The series of figures given in Table VI was obtained by the addition of an emulsion of 25 salivary glands of *G. tachinoides* to 1 cc. of sheep's blood, followed after one minute by the addition of an emulsion of a varying number of *tachinoides* mesentera. As before, the bulk of the fluid was kept constant.

TABLE VI.

Showing the Effect on the Coagulation Time of Blood of the Addition of a varying Quantity of Coagulant Enzyme of the Mesenteron to Blood previously treated with Anticoagulant Enzyme of the Salivary Glands.

Number of Salivary Glands.	Number of Mesentera.	Time of Coagulation.	
		Minutes.	Seconds.
0 (Control)	0	3	40
25	0 (Control)	21	0
25	2·5	20	30
25	5	19	45
25	7·5	19	15
25	10	19	0
25	15	17	45
25	20	17	0
0 (Control)	3 (Control)	0	35

These figures show a considerable delay in coagulation when compared with those of the preceding experiment. Thus, when the interval of one minute is allowed between the adding of 25 salivary glands and 10 mesentera, clotting is retarded by 15 mins. 20 secs., while in the former experiment the same quantities mixed before their addition to the blood accelerated the coagulation by 1 min. 20 secs., differences too great to be accounted for by any possible variation in the potency of the emulsions. Diagram 3 shows the curve obtained by plotting these figures. The great difference between this and the preceding curve seems to indicate that when the anticoagulant

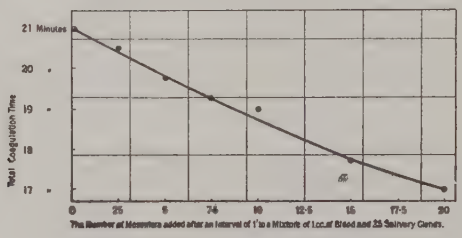

Diagram 3.

enzyme of the salivary glands is allowed to act on the blood first, as occurs in the fly, it neutralises first the free kinase present and then combines in some way with an element in the blood, so as to be less accessible to neutralisation by the coagulant enzyme of the gut.

In attempting to form a theory to explain the mode of action of these enzymes it is necessary to give some account of the sequence of events that takes place in normal clotting. The following is a greatly simplified account of some of the factors concerned in blood coagulation, according to the more generally accepted theories. The blood

plasma contains three active elements, namely, the fibrinogen, the precursor of fibrin ; prothrombin, the precursor of thrombin or fibrin ferment ; and thirdly, calcium salts. The tissues and the leucocytes supply another enzyme, kinase. Coagulation takes place in two stages ; firstly, the kinase acts upon the prothrombin in the presence of calcium salts to form thrombin ; secondly, the thrombin acts upon the fibrinogen to produce fibrin.

(1) Kinase + Ca + Prothrombin = Thrombin (Fibrin ferment).

(2) Thrombin + Fibrinogen = Fibrin.

The gut coagulant was found to be quite inactive with citrated blood and so has no effect in the absence of calcium. Using sheep's blood, the normal coagulation time of which was 3 mins. 30 secs., and an emulsion of $12\frac{1}{2}$ mesentera, which normally clotted this blood in 35 secs., no clotting occurred in 24 hours when the blood had been previously citrated. Similarly no clotting could take place when all the calcium had been removed by the addition of a little potassium oxalate. This can only be explained by the supposition that the mesenteric enzyme is not a direct coagulant of blood, such as thrombin, but rather that in the presence of calcium salts it acts on the prothrombin to form thrombin. Thus the gut enzyme is more or less akin to kinase, that is :

Gut enzyme + Ca + Prothrombin = Thrombin.

The form assumed by the curve in Diagram 2 and the points discussed in considering the action of heat on the emulsion of mesentera (see p. 45) indicate that the salivary and gut enzymes combine together in some way to form an inactive compound, that is :—

Salivary enzyme + Gut enzyme = Salivary Gut Complex (inactive).

As the salivary enzyme is complementary to the gut enzyme, which is itself akin to kinase, it is suggested that the former substance is not an antithrombin but rather something akin to antikinase.

Further evidence was obtained that the salivary enzyme plays no direct part in delaying the action of thrombin on fibrinogen by the following experiment. A solution of fibrinogen was prepared by the ordinary method of dissolving in 5 per cent. NaCl the precipitate obtained by the addition of saturated salt solution to salted plasma. A solution of thrombin was prepared by extracting with water the precipitate formed by adding four volumes of absolute alcohol to one volume of serum. An emulsion of 25 salivary glands would increase the coagulation time of 1 cc. of sheep's blood from 3 mins. 55 secs. to 55 mins., but it was found that the addition of this amount of salivary emulsion had no appreciable retarding effect on the clotting of the fibrinogen solution produced by a few drops of the extract of thrombin. Thus 2 drops of thrombin extract added to 1 cc. of fibrinogen solution caused clotting in 4 mins. 30 secs., and with the same quantities and the addition of an emulsion of 25 salivary glands the fibrinogen solution coagulated in 5 mins. 25 secs. This small difference in coagulation time could be readily accounted for by the impurities in the solutions used.

The delay in coagulation caused by allowing a short interval to elapse between the addition of the salivary emulsion and that of the mesenteron can be explained if the excess of salivary enzyme, after the neutralisation of all the free kinase present, combines in some way with an element in the blood, probably by adsorption by the prothrombin. With moderate concentrations of salivary enzyme the gradual formation by the leucocytes of more kinase would neutralise the salivary enzyme and so split up the adsorption compound until there was sufficient excess of kinase to form thrombin, that is :—

Salivary enzyme + Prothrombin = Salivary-Prothrombin Complex.

If the salivary enzyme is allowed to form this adsorption compound with the prothrombin, it will take a definite space of time for the gut enzyme, equivalent to

kinase, to liberate the prothrombin from the complex and so allow the excess of gut enzyme to produce thrombin, that is :—

1 Salivary-Prothrombin Complex + 2 Gut enzyme = 1 Salivary-Gut Complex + 1 Gut enzyme + 1 Prothrombin, and then :—

Gut enzyme + Prothrombin + Ca = Thrombin.

In this way we suggest that the anticoagulant enzyme of the salivary glands and the coagulant enzyme of the mesenteron are complementary and owe their activity to their influence on the preliminary formation of thrombin and not to any direct action on the thrombin itself. The gut enzyme being equivalent to kinase accelerates the reaction, and the salivary enzyme retards it. The latter substance is equivalent to antikinase, and any excess of it seems to be adsorbed by the prothrombin, so that as more kinase is formed it can only act on the prothrombin after the adsorption compound is split up. The anticoagulant enzyme of the salivary glands of *Glossina* appears to be quite different from hirudin, the anticoagulant enzyme of the leech, as this is said to be antithrombin, which acts directly on the thrombin to neutralise it.

5. Functions of the Organs of Alimentation and Excretion.

1. *Salivary Glands.*

The irritation and skin reaction that so often follow the bite of a bloodsucking insect show that in the act of feeding some irritant passes into the wound. Many people suffer little discomfort at any time from the bite of tsetse beyond the worry of the prick and the occasional sharp pain when the insect strikes a nerve ending, and in these the skin reaction is slight and ephemeral. Others find a large and itching wheal follow each bite, but generally they soon acquire a tolerance, and the exaggerated reaction no longer occurs. The purpose of this definite injection, as it was naturally supposed to be, has been obscure. It has been suggested that it causes blood to flow more readily and also that it prevents clotting before the blood can reach the midgut. A tsetse-fly from which the salivary glands have been removed can, however, usually feed as readily as a normal fly and do so repeatedly when all traces of salivary secretion have gone from its proboscis. A series of operations has shown this to be the case.

The fly has its wings cut off and is held with a pair of spring bow compasses by the thorax. With a very sharp needle an oblique cut is made on each side across the lateral dark patches on the second abdominal segment, the cut running to the edge of the abdomen close to the junction of the second and third segments. Through these cuts the salivary glands may be drawn out completely by means of needles and forceps, the fracture occurring just posterior to the junction of the ducts of the glands. After some practice the operation is easily performed with *tachinoides*, especially females which are slightly fat ; but it is difficult with *morsitans*, because the crop and sometimes a loop of the gut well up into the wounds and are liable to be ruptured. There is practically no bleeding from the incisions, which close quickly as sunken thick, black scars. There is no regeneration of the glands.

The operation was successfully performed on 28 *tachinoides*, which were subsequently fed on man and were usually ready to feed within half-an-hour of the removal of the glands. The majority were killed soon after the meal or on the day after the operation for purposes of examination, and some died on the second day, possibly from shock. Seven flies which did not suffer from shock and were kept alive had the following history :—One was killed on the 5th day, after taking 4 meals, because it could no longer draw blood ; one died on the 7th day after 5 meals ; one went into convulsions on the 7th day after 5 meals ; one was killed on the 10th day after 8 meals, when it was still active and apparently normal ; one was killed on the 14th day after 8 meals, being abnormal and unable to feed, but had produced a healthy larva on the 10th day ; another died on the 14th day after 13 meals ; one even survived till the 58th

day, taking 26 meals and producing healthy larvae on the 15th, 22nd, 42nd and 50th days respectively. This last fly was interesting, because it was the most efficiently draining fly that we have watched, always producing a pool of excreta before its meal was over, passing on one occasion 8 drops while still sucking, and to this efficiency is attributed its long life. It was several times sick, with uncontrolled movements of the limbs, and at times could not feed, though eager to do so, but overcame the difficulty the next day. In the end it failed to feed for three consecutive days and was killed for examination.

The operation was performed without apparent mishap on three female *morsitans*, which were then fed on man, taking full meals. One died the next day. The others took full second meals, and the day after that one being feeble was dissected, while the remaining one refused more food and became feeble on the fourth day after the operation.

The salivary glands were also removed from 13 *tachinoides*, which were subsequently put on a fowl to feed. Two could not feed on the fowl, and of these one took later a small meal from man. The rest fed well. Eight were dead or moribund by next day. Two survived three days, each taking two meals, one bursting its gut at the second meal ; one was feeble and was killed on the 4th day after taking 4 meals ; one survived 10 days with 10 meals on the fowl and generally fed quite well ; the remaining fly died on the 14th day after 13 meals on the fowl, but the last 4 meals were very small. The glandless flies therefore did less well on fowl than on man.

All the flies which survived the first 24 hours after the operation and retained their strength took a second meal, and ten fed repeatedly and well. From this it is clear that the injection of the salivary secretion into the host is not a necessary preliminary to the act of feeding, but rather in the nature of an accident, because the salivary secretion and blood mix at the very tip of the proboscis. We have attempted to show how this occurs in a diagram in which a cloud of salivary secretion is depicted as escaping out of the hypopharynx into the tip of the proboscis, which rests in the blood stream. Most of it passes back up the proboscis mixed with the indrawn blood,

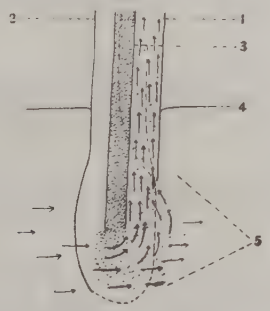

Fig. 4. Diagram illustrating diffusion of salivary secretion while a tsetse-fly is feeding : 1, labrum ; 2, labium ; 3, hypopharynx ; 4, skin surface ; 5, blood and salivary secretion mixed. The blood is represented by arrows, the salivary secretion by dots.

but some is carried away by the blood brushing past it and so is lost to the fly. It is this escape which causes the wheal at the site of the bite, and a fly from which the glands are removed causes no wheal even in a very susceptible person. A slight bruise, which may be as much across as a shilling and persist for several days, is sometimes caused in tender skin by the fly without glands just as by the normal fly, but this is not the result of any injection but of laceration of the tissues by the proboscis.

That the wheal is actually caused by the salivary secretion was further proved by injecting the skin of a sheep with an emulsion of 40 salivary glands in 0·1 cc. of saline. A raised conspicuous area nearly an inch long resulted in a few minutes, whereas the injection of the same amount of saline caused no skin reaction.

Although the salivary secretion which passes into the host must be regarded as a loss to the fly, it was found by the following experiment that a considerable quantity may so escape, especially when the fly bites but fails to feed. Twenty-five *tachinoides* were allowed to bite for about 5 minutes each through the thin skin of a small bird into 0·25 cc. of water. The flies find a mechanical difficulty in imbibing through thin skin, and also in drinking water, but one drew off a small meal and there was some escape of fluid through the skin (see below, p. 57). The fluid remaining, 0·15 cc., was mixed with 1 cc. of sheep's blood, of which the normal time of coagulation was 1 min. 50 secs. The coagulation was delayed to 5 mins. 45 secs., so the amount of salivary secretion injected was about equivalent to the quantity obtained from 10–15 emulsified whole glands. It is not to be supposed that the flies would inject so much in normal meals, as in this experiment only one was known to absorb fluid.

Sooner or later the fly which has been deprived of its salivary glands finds a difficulty in feeding, and this was, except in one case, the prelude to death. In some cases, though eager to feed, they could not insert their proboscides ; and in other cases, though the proboscides went in normally, no blood could be drawn. It was found by dissection of the flies during the first 24 hours after the glands had been removed that blood remained in the proboscis because there was no afterflow of salivary secretion to wash it down. In some cases there were soft clots in the crop, and in several the blood in the anterior part of the mesenteron had clotted firmly, though in this region in normal flies true clotting should not occur (see below, p. 56). The *post-mortem* findings in the 14 flies which survived two or more meals are shown in Table VII and are summarised as follows :—

Proboscis.—This always contained clotted blood, except in one case, when only a few cells were detected. Sometimes the whole proboscis was blocked by clot and had the appearance shown in fig. 5, which is a drawing of the labrum and hypopharynx of *G. tachinoides* no. 59. In one case the hypopharynx was blocked by clot at the tip.

Fig. 5. Labrum and hypopharynx of *G. tachinoides* from which the salivary glands had been removed showing the blood channel blocked by clotted fowl's blood. The fly was moribund twenty hours after feeding.

Oesophagus.—This contained clot with one exception (and in one case was not seen), and in flies which became feeble and could not feed there was always a large firm clot massed at the point where the oesophagus enters the proventriculus (fig. 6). This clot so evidently occluded the lumen of the gut that we came to regard its formation as the critical point in the life of the fly without salivary glands.

Proventriculus.—This contained clot with two exceptions (and in one case was not seen), but the organ is thick-walled and the cavity is convoluted, so that observation is not easy in the fresh preparation. In no case was there much blood in it.

Crop.—This contained clot with three exceptions, when it was empty. These clots were very large, and in two instances the whole duct leading from the proventriculus was also full of clotted blood. These crop clots become gelatinous and firm and cannot be utilised by the fly. They have been recorded by one of us from normal *G. morsitans* fed on fowl's blood in the laboratory, and it was shown how they

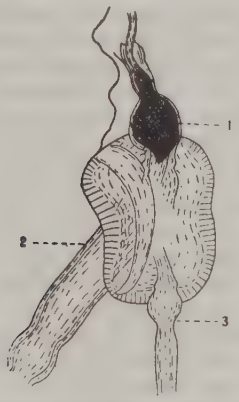

Fig. 6. Ventral view of proventriculus of *G. morsitans*, fed twice on human blood after removal of the salivary glands. The fly could not feed again on account of the clot occluding the lumen of the oesophagus. 1, clot in oesophagus; 2, mesenteron; 3, duct to crop.

distorted the reproductive organs of the females in some cases, so that they could not breed. On several occasions we have encountered them in wild flies at Sherifuri and the blood was found to be avian with one exception (ungulate blood), and in some cases the persistence of the clot is shown by the fact that it may have become quite dehaemoglobinised.

TABLE VII.

Giving the History of Tsetse-Flies deprived of their Salivary Glands.

Number.	Fed on.	Fate.	Day of Examination.	Meals taken.	Post-mortem findings (Clot ±; Normal —)				
					Proboscis	Oesophagus	Proventriculus	Crop	Mesenteron (anterior part)
G. tachinoides									
47	Man	Choked	5th	4	±	±	±	±	—
64 ...	,,	Died	7th	5	±	±	±	±	—
48	,,	Convulsions	7th	5	±	±	±	—	±
13	,,	Still active	10th	8	±	± (small)	±	—	—
7	,,	Died	14th	13	±	±	±	±	?
42	,,	Choked	14th	8	±	±	—	—	±
46	,,	Choked	58th	26	±	±	±	±	±
60	Fowl	Burst Gut	3rd	2	±	±	±	±	?
61	,,	Died	3rd	2	±	?	?	±	±
21	,,	Feeble	4th	4	blood cells	±	±	±	—
59	,,	Died	10th	10	±	±	±	±	—
62	,,	Died	14th	13	±	±	±	±	± (little)
G. morsitans									
37	Man	Feeble	3rd	2	±	±	±	±	—
39	,,	Feeble	4th	2	±	—	—	±	(unhealthy)

Mesenteron.—Blood normally coagulates in the posterior part, and there also occurs a pseudoclotting (see below, p. 56) which can hardly be distinguished from physiological clot, so that it is not surprising that in 6 of the flies the condition in this region appeared normal. The salivary secretion, however, is ordinarily present in the anterior part of the midgut and prevents physiological clotting till the blood passes backwards, as otherwise the meal may be constricted by the folds of the gut. The effect of the lack of it was seen in several cases. In *G. tachinoides* no. 42, after 8 meals on man followed by 4 days of starvation before it was dissected, blood was found in the mesenteron, which should have been empty, and was collected in three large masses of hard clot separated by constricted gut. In 4 *G. tachinoides* fed on fowls' blood it was found that the blood had not passed back normally in the midgut, and in one of these there was a large firm clot confined to the anterior part.

These facts prove that the anticoagulant enzyme in the salivary secretion is to prevent the clotting of the blood in the narrow anterior channels of the alimentary tract, to keep the blood fluid in the crop till it can repass up the narrow duct into the midgut (a period of 2–3 hours), and to facilitate its movement in the mesenteron. The secretion, apart from this main function, also flushes the proboscis and oesophagus, and keeps the former moist. It probably plays no further part in digestion than this mechanical one, as flies without glands can live long and breed, so that their power of assimilating food cannot have been seriously impaired by the lack of it.

2. *Crop.*

Fig. 7 illustrates the normal distribution of blood at a full meal and shows the large proportion of the blood which passes into this organ. If a fly is interrupted in its meal directly distension can be detected, it is found that no blood has entered the crop, all having passed to the midgut. It has been pointed out above that the final stage of the meal when blood flows into the crop is exceedingly rapid. It appears that as soon as there is any back pressure in the midgut the passage to the crop opens, but not before. If the crop is destroyed by pricking, it is found that the

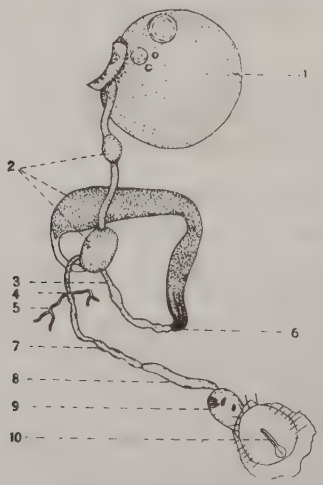

Fig. 7. Dissection of gut of tsetse-fly 10 minutes after feeding: 1, crop, blood and gas bubbles; 2, localised blood in mesenteron; 3, posterior mesenteron, contracted; 4. sphincter mesenteri, closed; 5, Malpighian tubes; 6, blood clot; 7, prorectum in active peristalsis; 8, mesorectum, distended with urine; 9, metarectum, distended with urine; 10, anus.

mesenteron takes up more blood at subsequent meals. Its function is therefore to allow the fly to take a full meal rapidly with little risk of rupture of the intestine, and the gas which it contains evidently aids in the expulsion of the blood from this membranous organ as room for it develops in the midgut (fig. 8).

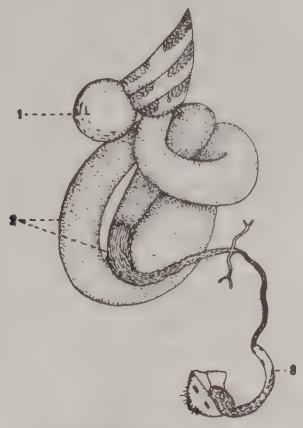

Fig. 8. Dissection of gut of *G. tachinoides* 2½ hours after feeding : 1, crop, bubble of gas and film of blood ; 2, mesenteron, fully relaxed ; 8, mesorectum, mixed urine and faeces.

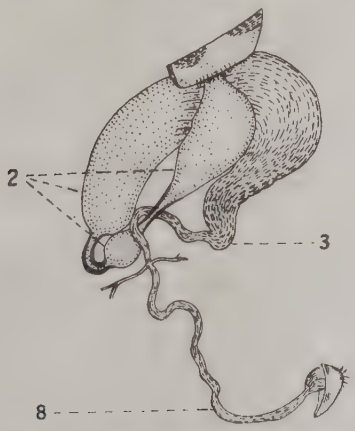

Fig. 9. Dissection of gut of *G. tachinoides* 24 hours after feeding : 2, mesenteron, localised blood ; 3, posterior mesenteron, still relaxed ; 8, mesorectum, no longer distended.

3. *Mesenteron.*

The whole of the assimilation of food takes place in this portion of the alimentary tract. The behaviour of the mass of blood is shown in a series of four figures drawn at various intervals after a full meal from rapidly dissected specimens, the main details being obtained while the tissues were still living. Fig. 7 shows the condition ten minutes after a meal. The little blood in the midgut is localised in three regions

by pressure on the folds of the gut. It has been brought up sharply at the point where the circular muscle layer is increased, and at this spot a blood clot, conventionally depicted, has formed by the action of the coagulant enzyme, while the rest of the blood is still fluid and bright red. Fig. 8 was prepared $2\frac{1}{2}$ hours after the meal. Most of the blood has passed out of the crop, a remaining film being pressed by the bubble of gas against the anterior face, where the duct opens. The mesenteron has relaxed and there is no longer any abrupt demarcation where the narrow portion begins. The blood is still bright red anteriorly, darkening behind to almost black. Fig. 9 shows the condition after 24 hours. The crop being empty is not forced out in the dissection. The anterior part of the midgut is contracting, the hinder part being still relaxed, and the blood is again much confined to regions by the folds ; it is clear at this stage that firm clotting of the blood in the anterior bulges would be a disadvantage. Pseudoclotting is now well marked, the blood in the forward parts having all the appearance of a soft plastic clot, but this is due to the fact that

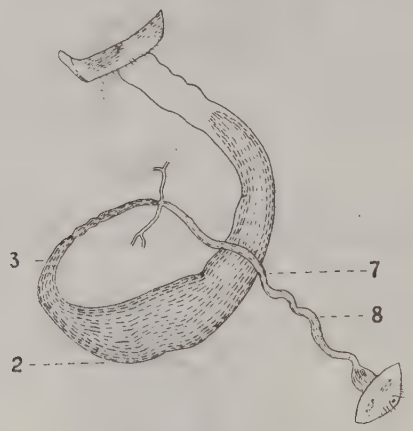

Fig. 10. Dissection of gut of *G. tachinoides* 48 hours after feeding: 2, mesenteron, all blood semi-digested; 3, posterior mesenteron contracting; 7–8, prorectum and mesorectum uniform.

most of the plasma has been absorbed and the massed red cells lie in a mucilaginous matrix derived from the gut secretions. The same type of pseudoclotting is found when the flies are fed on citrated blood and also on a suspension of washed red cells both in sheep's serum and in saline, mixtures in which true clotting could not occur. Fig. 10 shows the condition 48 hours after the meal. All pressure has gone, so that the folds of the gut no longer constrict the remainder of the meal. The posterior part of the midgut is still somewhat relaxed, but is assuming its normal contracted appearance. All the meal is very dark, and the anterior end of it lies in clear mucilage.

The function of the powerful coagulant enzyme of the hinder part of the midgut appears to be that it prevents the blood from passing too far back before it has been acted on by the digestive secretions. At the same time the clot gives the narrow posterior part time to relax slowly, and this no doubt helps to prevent rupture. The sphincter muscle which ends the mesenteron is normally closed in the act of feeding, and for some time afterwards, but on two occasions when flies were being fed on citrated blood some passed through and out at the anus, in one case a few drops only, but in the other almost the whole meal was lost, and the fly was incapacitated through becoming befouled by the escaping blood. The coagulant would prevent such an accident.

4. *Malpighian Tubes.*

These are known to act as excretory organs. " The waste products stated to be eliminated by the Malpighian tubes (in insects generally) are extremely varied and include uric acid, urates of soda, lime and ammonia ; also urea, oxalate and carbonate of lime, carbonate of soda, phosphate of lime and Leucine " (Imms[6]). The excretion of water is not mentioned but is implied in this summary, and the elimination of the excess of this becomes one of the main functions of these organs in the tsetse-fly. For reasons of safety it is important that it should lighten itself after a distending meal as quickly as possible, and in addition to this, the crop should empty itself into the midgut before coagulation of the blood takes place, as the amount of salivary enzyme mixed with it does not delay clotting indefinitely. Rapid draining of the meal is therefore essential. In order to obtain an estimate of the speed and amount of drainage 5 male *G. morsitans* were weighed before a meal, just after, and at intervals of 15 mins., 1 and 23 hours afterwards, respectively. The wings were cut off to facilitate the weighing, and the flies were transferred to clean weighed tubes at each operation. The average results from the five were as follows : Initial weight, 0·0236 gm. ; blood taken, 0·0395 gm. ; drainage in 15 mins., 0·0112 gm. ; drainage in 1 hour, 0·0169 gm. ; total loss, drainage and faeces, in 23 hours, 0·0254 gm. In other words, the fly in 15 mins. drains away 28 per cent. of its meal, in one hour 43 per cent., and in 23 hours 64 per cent., some faeces being included, actually more than its initial body weight.

That all the clear fluid exuded passes through the Malpighian tubes can be demonstrated by opening the fly during the process of active draining, when the flow can be seen in the common ducts of the tubes, and the whole of the meso- and metarectum are found to be distended by it. Later, white flakes can be seen passing down the common ducts in the urine, for such it may be called. It can also be proved by feeding the flies through skin on saline solution containing methylene blue, and still better by feeding them on laked red cells in saline, that nothing passes out by the direct route during the first hour after a meal, as in each of more than 100 tests only uncoloured fluid passed in this time. A long series of similar experiments was carried out when we were searching for a reason for the presence of the coagulin in the midgut, as the first obvious suggestion was that the purpose of the clot was to express the serum from the blood in order to concentrate it and that the clear fluid passed might be serum as Newstead, Dutton & Todd thought[2] (Newstead's " Guide," p. 134). It is not necessary to detail all these experiments, but a few of the more interesting points may be noticed. The fluid was placed in a small flask over the mouth of which a piece of the skin of a bird, monkey, rat or lizard, was stretched by means of an elastic ring, this being much the same method as other workers have employed.[3, 7] The flies feed more readily through the thicker skins of vulture, fowl or monkey, than through thin skins of small birds, rat or lizard. By this means we induced the flies to feed on a wide range of fluids, including citrated blood up to 5 per cent. citrate, various strengths of saline up to 5 per cent., and water. The only fluid tested which was entirely refractory was milk, for though the flies were eager enough and tried for long to feed, no fluid was absorbed, there being some mechanical difficulty. They do not feed so readily or so rapidly on salines or shed blood as on the living animal. They do, however, take fluids containing red cells, whether whole or laked, more readily than those containing none, a confirmation of the findings of Yorke & Blacklock.[1] They take a fluid with an osmotic pressure not far from that of blood more readily than one which is highly hypertonic or hypotonic ; thus is one experiment, the flies (*morsitans*) trying all the time to feed, 7 fed on normal saline, averaging 15 mins. (5–30 mins.), 4 fed on water averaging 36 mins. (15–64 mins.), and 4 fed on 2·5 per cent. saline averaging 29 mins. (12 –70 mins.). When the osmotic pressure of the fluid was much above or much below that of blood, draining did not take place, or was very slow. This was first noticed when the flies had fed on citrated whole blood (1 per cent. citrate). Table VIII summarises the results of feeding flies, *G.*

morsitans and *tachinoides*, on saline solutions. It shows that flies can drain normally concentrations of saline from about 1 per cent. down to 0·4 per cent. NaCl. Above 2 per cent. or below 0·2 per cent. few flies could drain at all. Feeding on very low concentrations or on water, when the fly took a full meal, was followed by a collapse that was sometimes dramatic, the fly even falling off the skin in a moribund state. Several of these emptied themselves while in a state of collapse by way of the relaxed sphincter mesenteri, and one did so after death. Two thus survived the meal of water, but one of these given subsequently a meal of blood collapsed again and died. It seemed possible that death might be due at least in part to prolonged pressure on the tracheae and blood-vessels, but that this is not the case was proved by a simple experiment. Six *G. tachinoides* had the tip of the abdomen dipped into melted wax and were then given a full meal from man. The sealing was successful in three cases and there was neither drainage nor collapse in 48 hours, when they were dissected. The gut posterior to the Malpighian tubes was gorged with excreta, and the tubes themselves were congested with solid matter. Much faecal matter was mixed with blood in the midgut, and the blood in the crop had clotted because there was no room for it to pass into the midgut. Water in large quantities must be regarded as a tissue poison to tsetse-flies. When a fly which has been gorged with water has its skin pricked, an unusual quantity of fluid exudes, showing that part of the meal has passed the gut wall, but the Malpighian tubes cannot deal with it and death is probably due to cell destruction caused by irritation due to differences in the osmotic pressure.* On the other hand, when a fly which has been fed on strongly citrated blood is opened, the mesenteron is found to be enormously distended, pseudoclots of blood lying in a clear mucilaginous fluid, which has been drawn into the lumen of the gut by the hypertonic meal, while the hindgut is collapsed and flaccid. Flies so fed on citrated blood develop a pronounced hunger sickness, and in spite of their great distension they return again and again to the skin and try to feed.

TABLE VIII.

Showing the Relation between the Activity of the Malpighian Tubes and the Osmotic Pressure of imbibed Fluids in Tsetse-Flies.

Concentration of NaCl.	Number of Flies Fed.	Speed of Drainage.	Effect on Flies.
5·0 per cent.	3	None	Fatal
2·5 ,, ,, ...	4	3 none, 1 retarded	Fatal
1·75 ,, ,, ...	1	Retarded	Survived
1·5 ,, ,, ...	2	,,	1 died, 1 survived
1·25 ,, ,, ...	4	2 normal, 2 retarded	2 died, 2 survived
1·0 ,, ,, ...	6	Normal	Survived
·9 ,, ,, (normal) ...	16	,,	3 died, 13 survived
·5 per cent.	2	,,	Survived
·4 ,, ,, ...	3	,,	,,
·3 ,, ,, ...	2	1 normal, 1 retarded	,,
·2 per cent.	4	Retarded	,, , 2 drained in collapse
·1 ,, ,, ...	5	1 retarded, 4 very little	2 survived, 4 collapsed, 1 drained in collapse.
·05 ,, ,, ...	5	1 retarded, 4 none	1 survived, 4 collapsed, 1 drained while moribund
Water	13	1 retarded, 12 none	All collapsed, 2 drained in collapse with partial recovery

Note. Retarded drainage probably takes place through the relaxed sphincter mesenteri.

* It has been pointed out to us that water poisoning is known among certain miners who work in hot mines and sweat profusely. Large quantities of water taken under such conditions are apt to cause cramps and even death. The addition of salt to the drinking water or the eating of highly salted foods, such as bacon, is a preventive measure.

5. *Hindgut.*

The sphincter which ends the mesenteron serves a double purpose. It holds back the meal, allowing only waste products to pass, and in the act of opening it closes the common ducts of the Malpighian tubes, so that faecal matter cannot enter them. The valve may be seen very well in a fly which has been flushed out with a meal of saline, and if such a fly is opened while its tissues are still living, its mechanism is quite clear (fig. 2).

The prorectum is a narrow portion of the gut which is never seen distended, and peristalsis in this region is particularly active. The nipple-like valve which ends it and protrudes into the mesorectum serves to prevent back pressure on the Malpighian tubes while these are excreting. This is very clear in a newly gorged fly rapidly dissected (fig. 3).

The mesorectum is a distensible tube which may be seen much distended when the fly is actively draining (figs. 7 and 8), but when active drainage has ceased and mainly faeces are passing, it is barely distinguishable from the prorectum. During drainage it thus functions as a urinary bladder, which allows the accumulation of a relatively large drop of urine to form before it passes to the metarectum. The very small opening by which it communicates with the metarectum and the position of this pore on the dorsal surface of the latter region appear to form also a valvular device. The arrangement suggests a pulsating rhythm between the two regions, but as the anus does not allow fluid to pass in the dissected fly, such rhythm has not been observed. By such an alternating distension urine may pass very quickly but always in large drops which fall clear, so that dribbling, which would foul the fly, is avoided. Besides acting as a second bladder during drainage, the metarectum also stores faeces during later digestion.

The rectal papillae are probably excretory organs, and the following experience suggests that they are concerned in the elimination of the excess of calcium. In a group of 6 *G. tachinoides* fed on citrated blood (1 per cent. citrate), which were dissected the day after the meal, it was found that in 5 flies the metarectum contained hard calcareous masses, probably mainly calcium citrate ; in two cases a single large mass filled the whole chamber and in three there were several pieces of varying size in a dark semi-fluid mass ; in the remaining fly, which had not drained, there were no concretions. In a group of 9 *G. morsitans* similarly treated the calcareous masses were found in only one fly. These masses must have been concreted *in situ*, as they were too large to pass the constrictions of the gut.

6. Summary.

(1) The salivary glands of *Glossina* contain a powerful anticoagulin, which delays the clotting of blood of mammals, birds, reptiles and batrachians. It was found that when the salivary glands are removed from the living fly, it can still draw blood normally and may live long, but sooner or later large clots form in the narrow anterior portions of the alimentary tract, so that the fly can no longer feed and dies of starvation. The purpose of the anticoagulin is to prevent such clotting and blood coagulation in the crop.

(2) The proventriculus and first third of the mesenteron are themselves inert in relation to coagulation of blood, but as removed from the normal fly they contain the anticoagulin which is derived from the salivary secretion.

(3) The hinder part of the mesenteron contains a powerful coagulin, the purpose of which is to neutralise the anticoagulin and cause a rapid clotting, in order to retain the fluid meal in the proper region while draining and assimilation take place, probably also to save strain on the sphincter mesenteri and prevent the occasional loss of food through the anus.

(4) Both enzymes have all the ordinary properties of ferments, the salivary enzyme being rather the more stable of the two. When mixed they probably unite by some weak chemical action and form an inactive compound. It also appears probable that the salivary enzyme combines loosely with some element in the blood in such a way that its neutralisation by the coagulant enzyme is delayed. The salivary enzyme is believed to intervene in what is considered to be the first phase of clotting, the formation of thrombin, and to be akin to antikinase. As the mesenteric enzyme has no effect on blood from which the calcium has been removed, it is not akin to thrombin and probably also influences the first phase of clotting, acting like the enzyme kinase.

(5) Very rapid draining of the meal is necessary to lighten the fly and allow the blood to pass from the crop to the midgut while the salivary secretion still prevents its clotting. The mechanism of draining is described. The Malpighian tubes only function properly when the fluid of the meal has an osmotic pressure near that of blood. A large meal of water kills the fly, generally rapidly.

(6) The names pro-, meso-, and meta-rectum are proposed for the regions of the hindgut.

References.

(1) Cornwall, J. W. & Patton, W. S. Some Observations on the Salivary Secretion of the Commoner Blood-Sucking Insects and Ticks.—Ind. Jl. Med. Res. ii, no. 2, 1914.
(2) Newstead, R. Guide to the Study of Tsetse-Flies.—Liv. Sch. Trop. Med. Memoirs.
(3) Austen, E. E. & Hegh, E. Tsetse-Flies.—Imp. Bur. Entom.
(4) Macfie, J. W. S. Experiments and Observations upon *Glossina palpalis*.—Bull. Ent. Res., iii. pt. 1, 1912.
(5) Lloyd, Ll. Further Notes on the Bionomics of *Glossina morsitans* in Northern Rhodesia.—Bull. Ent. Res., v, pt. 1, 1914.
(6) Imms, A. D. Textbook of Entomology.—London.
(7) Yorke, W. & Blacklock, B. Food of *Glossina palpalis* in the Cape Lighthouse Peninsula, Sierra Leone.—Ann. Trop. Med. & Paras., ix, 1915.

TWO NEW SPECIES OF *CICADULINA*, CHINA (HOMOPTERA, JASSIDAE) FROM THE GAMBIA, WEST AFRICA.

By W. E. China.

The genus *Cicadulina* was erected in 1926 (Bull. Ent. Res., xvii, p. 43) to hold *C. zeae*, a new species injurious to maize in Kenya Colony. Thanks to the kindness of Mr. T. J. Naudé, I have since been able to examine specimens of *Balclutha mbila*, Naudé, which has been recorded as transmitting the virus of streak disease of maize in Natal. This species is undoubtedly congeneric with *C. zeae* and differs from typical *Balclutha* species in the shape of the head and pronotum, and in the venation of the tegmina. It should, therefore, be known in future as *Cicadulina mbila*, Naudé.

Unfortunately Herr H. Haupt, of Halle, in Saxony, has recently used the name *Cicadulina* for another new genus of Jassidae, allied to *Cicadula*, Zett., and recorded from Palestine (Zionist Organisation Inst. Agric. & Nat. Hist., Tel-Aviv, Palestine; Exp. Sta. Bull, 8, p. 38, Aug. 1927). I therefore propose the new name **Cicadulella** for *Cicadulina*, Haupt 1927, *nec* China 1926.

The following new species were collected from ground-nut plots in the Gambia and forwarded to the Imperial Bureau of Entomology for determination by Mr. A. J. Brooks, the Director of Agriculture of the Colony.

Cicadulina arachidis, sp. nov. (fig. 1, *a*, *b*, *c*, *d*; fig. 2, *b*, *b'*).

♂ ♀. Pale egg-yellow, abdomen and legs paler; the clypeus, frons and middle of vertex, deeper in colour; two round spots above ocelli, and the apices of the rostrum and ovipositor black. Eyes, except anterior margin, grey with the posterior half blackish. Antennal flagellum, mesonotum, metanotum and basal tergites of abdomen, more or less infuscate, the colouring sometimes extending more towards the apex of the abdomen. Front tibiae slightly, and all the claws, infuscate. Tegmina, uniform pale translucent greyish yellow, immaculate, the nervures of the same colour. Wings whitish hyaline, veins pale. Median projection of last ventrite marked with brown. Relative length of vertex compared with pronotum 13 : 23. Length from apex of head to apex of clypeus compared with breadth of head across eyes, 39 : 42. Last ventrite of female (fig. 1, *d*), and male genitalia (fig. 2, *b*) figured. Total length including tegmina, ♀ 2·8 mm., ♂ 2·5 mm.

Gambia: 1 ♂, 2 ♀♀, vii-ix. 1927, from ground-nut plots; 1 ♂, 4 ♀♀, 1928, "on germinating ground-nuts" (*A. J. Brooks*).

Easily distinguished from *C. mbila* (fig. 2, *a*), by the absence of the brown streak down each tegmen; also by the shorter and thicker aedeagus with much shorter appendages (fig. 2, *b*). The median projection of the last ventrite, however, is very similar in the females of the two species. This species resembles *C. zeae* from Kenya in the unstriped tegmina, but the latter is a much larger insect (3·2 mm.* instead of the 2·8 mm. of *C. arachidis*), with rather darker tegmina, and has the eyes and the dorsum of the abdomen, except the lateral margins and apical tergite, entirely black, dark brown wing veins, and the median projection of the last ventrite in the female broader and less prominent.

* The length of *C. zeae* was unfortunately omitted in the original description (Bull. Ent. Res. xvii, pt. 1, July 1926, p. 43).

Cicadulina similis, sp. nov. (fig. 1, *e, f, g, h*; 2, *c, c'*).

♂ ♀. Pale egg-yellow, rather deeper on the frons and clypeus; legs and venter paler, genital segments almost white; posterior half of eyes, two round spots above ocelli, apices of rostrum and ovipositor, and dorsum of abdomen (except lateral margins and apical tergites), black; anterior margin of pronotum behind eyes, lateral basal angles of pronotum, tarsal claws, and median projection of last ventrite in ♀, infuscate. Tegmina semi-hyaline, the costal margin and the inner half of clavus

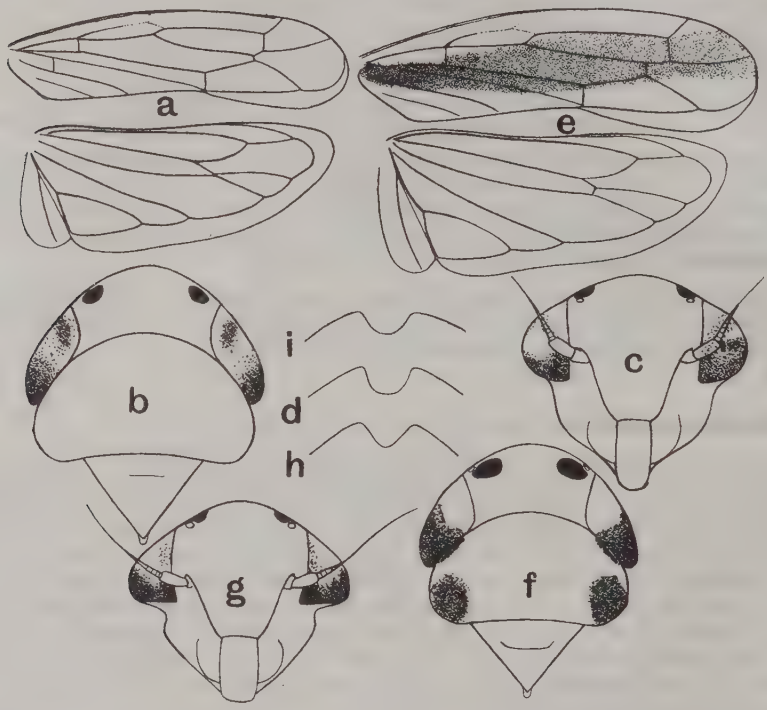

Fig. 1. *Cicadulina arachidis*, sp. n.: *a*, tegmen and wing; *b*, dorsal view of head and pronotum; *c*, ventral view of head; *d*, posterior margin of last ventrite of ♀.
Cicadulina similis, sp. n.: *e*, tegmen and wing; *f*, dorsal view of head and pronotum; *g*, ventral view of head; *h*, posterior margin of last ventrite of ♀.
Cicadulina mbila, Naudé: *i*, posterior margin of last ventrite of ♀.

yellowish white, opaque; a pale brown stripe extending down the middle between the whitish areas, becoming paler towards the apex of tegmen. Wings hyaline, veins brown. In the male the colour is rather deeper and the infuscations, especially the stripe on the tegmen, more pronounced. Relative length of vertex compared with pronotum (♀), 12 : 21. Length from apex of head to apex of clypeus compared with breadth of head across eyes (♀), 38 : 42.

Last ventrite of female and male genitalia figured (figs. 1, *h*, and 2, *c, c'*).

Total length including tegmina, ♀ 2·5 mm., ♂ 2·4 mm.

GAMBIA: 3 ♀♀, vii–ix. 1927, from ground-nut plots; 3 ♂♂, 2 ♀♀, 1928, "on germinating ground-nuts" (*A. J. Brooks*).

Very close to *C. mbila*, but smaller; the brown strips on tegmina slightly paler; only the basal half of the eyes black; ovipositor yellowish white, with black tip,

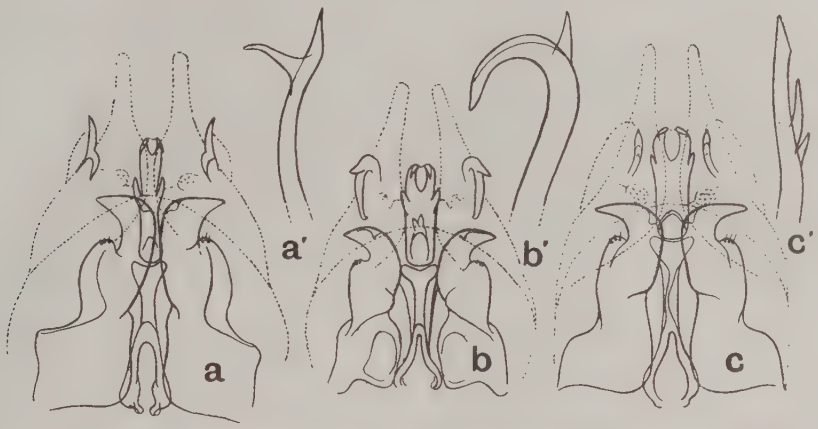

Fig. 2. Ventral view of male genitalia: *a*, *Cicadulina mbila*, Naudé; *b*, *C. arachidis*, sp. n.; *c*, *C. similis*, sp. n. Lateral view of male genital style: *a'*, *C. mbila*, Naudé; *b'*, *C. arachidis*, sp. n.; *c'*, *C. similis*, sp. n.

instead of pale brown with black tip; rostrum slightly longer; median projection of last ventrite in female more angular and less rounded; aedeagus of male shorter and much thicker, and the genital styles with the apical barbs not divergent (fig. 2, *c'*).

A NEW STAPHYLINID BEETLE PREYING ON RED SPIDER IN MAURITIUS.

By Malcolm Cameron, M.B., R.N., F.E.S.

Oligota (Holobus) pallidicornis, sp. n.

Convex, black, shining; antennae and legs yellow. Length, 0·75 m.m.

Near *O. flavicornis*, Lac., but smaller, the 8th and 9th joints of the antennae more strongly transverse, the fore-parts less closely punctured. Head extremely finely, sparingly punctured. Antennae with 3-jointed club, the 8th and 9th joints twice as broad as long, the 10th short, oval. Thorax twice as broad as long, very finely, moderately closely punctured. Elytra a little broader than and about half as long again as the thorax, very finely, moderately closely, asperately punctured. Abdomen strongly narrowed from base to apex, finely and moderately closely punctured on the anterior segments. The whole insect covered with a short, stiff black pulescence, the fore-parts with an extremely fine, more or less transverse ground sculpture.

Mauritius: Rose Hill, 1927. Found on manioc preying on red spider mites.

Type in the British Museum.

NATURAL ENEMIES OF *SIREX CYANEUS*, FABR., IN ENGLAND AND THEIR LIFE-HISTORY.

By R. N. Chrystal,
Imperial Forestry Institute,
and
J. G. Myers,
Imperial Bureau of Entomology.

(Plate III.)

1. Introduction.

It has long been known that the wood-wasps of the genus *Sirex*, wherever they occur, are parasitised by large Pimpline Ichneumonidae belonging to *Rhyssa* and closely allied genera. There was also strong circumstantial evidence that the aberrant Cynipids of the subfamily Ibaliinae attack the same hosts. Unfortunately both these groups of parasites, especially in England, are considered by no means common, and *Ibalia* has been regarded as one of the rarest of all Hymenoptera. In these circumstances, the usual obscurity surrounding the biology of wood-boring insects was tremendously augmented, and the data recorded on the life-history have been extremely meagre. The investigations, on which the present paper forms a preliminary report, were undertaken by the Farnham House Laboratory of the Imperial Bureau of Entomology, in collaboration with the Imperial Forestry Institute, to fill some of the gaps in our knowledge and to discover means of introducing one or both of these parasites into New Zealand as a measure against the steel-blue wood-wasp, which has been accidently introduced into that country. Although the study was begun only in July last, sufficient data have been accumulated to indicate the main features of the life-history of *Rhyssa persuasoria*, L., and of *Ibalia leucospoides*, Hochenw., and it seems desirable to place on record the main facts. During the coming season it is hoped to elucidate further details with a view to publishing a comprehensive account of these parasites and of their host. All purely morphological considerations will be deferred till then.

We owe a debt of gratitude to the President and Fellows of Magdalen College, Oxford, for granting us every possible facility to carry out field work at Tubney Wood. In view of the rarity—apparent or real—of the parasites we wished to study, the first desideratum was a locality where these occurred in sufficient numbers to allow systematic observation. Tubney fulfilled these requirements in a remarkable manner.

We are indebted also to Dr. J. Waterston for deciding authoritatively the specific identity of both parasites and of their host. This was by no means a simple matter.

2. The Locality.

The part of Tubney Wood, where practically the whole of the field work was accomplished, consists of a stand of larches and pines, many of the former of which (*Larix europaea*, D.C.) are obviously growing in a situation far too damp for their general health. These manifestly unhealthy trees, many of which were in a dying state, brought about by adverse physiological conditions, were also considerably infested with the Longicorn beetle, *Tetropium gabrieli*, Weise, and supplied nearly all our material of *Sirex* and its parasites. *Sirex* oviposited in those still bearing much green foliage, *Ibalia* followed close on the heels of its host, while *Rhyssa* laid its eggs in trees containing nearly full-fed wood-wasp larvae. The abandoned tunnels were utilised by hosts of Crabronids and by a species of *Odynerus* (*O. gracilis*) for

storing their prey. These trees were thus the central organisms of a well defined and exceedingly interesting biocoenose which merits a study extending over a number of seasons.

3. **Rhyssa persuasoria,** L.

With a more detailed account in preparation it does not seem necessary to attempt here a complete bibliography. Perhaps the fullest of the older papers is that of Riley (1888), who showed that up to that time the notion was widely prevalent that the female *Rhyssa* or *Thalessa*, boring through bark and wood with its long ovipositor, inserted its eggs actually into the host larva. Riley gives evidence that this latter is not the case, and figures the young *Megarhyssa* (*Thalessa*) larva attached to the abdomen of a *Tremex* grub. Yet even in recent years it has been claimed that the older theory is correct and that *Rhyssa persuasoria* has an endophagous larva. Bordas (1917) describes an egg which he found in the general body cavity of a *Sirex* larva, just above the digestive tract. He attributes this egg to *Rhyssa* and even goes so far as to suggest that the liquid from the "glandes venimeuses," which he dissected, is injected into the victim at oviposition to produce anaesthesia and to prevent decay of the larval tissues. There was no evidence for this, and no indication that the egg found was that of *Rhyssa*.

One of the writers, enquiring into the subject on the continent in 1925, found the endophagous theory widely held in France (Barbey, 1925, p. 703; Hubault, *in litt.*). In Germany, however, Escherich and Eidmann were both sure that Riley's hypothesis was the correct one, and that *Rhyssa* laid its eggs in the burrow, on or near the host larva. Stebbing, also, subscribed to the same opinion in India, from his observations on *Rhyssa persuasoria* as a parasite of *Sirex imperialis*.

More recently Torka (1926) has published observations which he thinks indicate that *Rhyssa* uses the oviposition-bore of the *Sirex* in its own egg-laying. He disturbed a *Rhyssa* with its ovipositor sunk in a lightning-struck fir on which numerous *Sirex* females were ovipositing. The *Rhyssa* flew away, leaving its instrument stuck in the still green wood. Torka did not ascertain, as can be easily done, whether the ovipositor *had* entered a *Sirex* bore. He suggested that it had:—"In irgend einer Weise muss doch die Möglichkeit bestehen, dass der bis 65 mm. lange Böhrer der Schlupfwespe, der dabei so dunn und biegsam ist, gänzlich in das harte Holz versenkt werden kann." We shall see later that *Rhyssa*, however, has no difficulty in penetrating the soundest larch wood; but there is some evidence that when the tree, as in the above case, is still green, the ovipositor is hard to withdraw. This, coupled with sudden disturbance, probably accounts for most of the cases of ovipositors broken off in the wood; though Stebbing further suggests that old females, laying their last egg, may die naturally in this position, as he finds do also some Scolytid beetles.

Riley, and especially Miss Cheesman (1922) among others, believe that the *Rhyssa* larva wanders along the *Sirex* burrows devouring perhaps a number of grubs. It is true that the *Sirex* burrows sometimes, though rarely, cross one another; but there is not the slightest indication that the *Rhyssa* larva is any more capable of traversing these tunnels, closely packed with extremely hard, compacted frass, than of boring through the hardly more solid wood. Miss Cheesman has interpreted small *Rhyssa* larvae, found alone in burrows, as not yet full-fed. It is certain that this is incorrect, and that diminutive larvae are merely ones which have fed upon a small host grub, the size of the latter being due either to youth or to that general variation so frequent and so large in the dimensions of wood-feeding insects.

Oviposition.

The oviposition of *Rhyssa*, in correlation with the shorter ovipositor, is strikingly dissimilar to the process in *Megarhyssa* (*Thalessa*) as described by Riley and later

workers. It resembles distinctly that of *Ephialtes* figured and described by Dingler (*cf.* also Bischoff, 1927, fig. 158). The extraordinary bladder-like outgrowth of the membrane between abdominal segments vii and viii (Baumann, 1924), which functions so conspicuously to receive the basal portion of the stylets when *Megarhyssa* is boring, is scarcely represented in *Rhyssa* save by a certain stretching of the intersegmental membrane in question.

But to begin with the preliminary exploration ; the female *Rhyssa* crawls slowly over the bark, palpating the surface with antennae outstretched, fairly close together and curved downward. Apparently when the host larva is more nearly approached, the play of the antennae becomes more rapid, more circumscribed, and the ends of these organs are bent right over, downward and backward, so that even the dorsal surface of the tips may touch the wood.

When actual boring is to begin the ovipositor is brought downward and forward, by elevating to the utmost extent the abdomen, and standing almost on the head, the legs and antennae being meanwhile held rigid. The instrument seems to be held between the bases of the third coxae, and even to pass between the second (*cf.* also Johnson, 1919 ; Cheesman). By this means it is brought to a position at right angles with the surface and boring begins. As it proceeds, the ovipositor sheath is gradually disengaged, forming occasionally and for a time, a loop above the abdomen as in *Megarhyssa* though less conspicuously ; but finally taking up its usually caudal position in line with the long axis of the body. Johnson's belief that the sheath enters the wood with the terebra, is thus erroneous, and there is no doubt whatever that the egg passes down the channel between the stylets, extraordinarily small though this passage is. A single oviposition may take from 20 to 40 minutes.

There is also no longer any question as to the ability of *Rhyssa* to pierce, almost up to the hilt of the ovipositor, the soundest wood.* The resulting passage is much too narrow to admit a human hair, and is consequently very difficult to trace.

A very surprising feature is the large number of futile borings made by the females of *Rhyssa* in wood which contains no trace of *Sirex* or its burrows anywhere in the vicinity of the puncture. In some cases these borings penetrate only a few millimetres, but in others the instrument is buried to its usual depth. We unfortunately kept no figures of all the attempts observed ; but it is certain that at least 90 per cent. were apparently unsuccessful. In one case a *Rhyssa* was observed to make five punctures, all moderately deep and we afterwards proved that no *Sirex* was present in the log within several feet. The frequency of these so-called " errors of instinct " on the part of *Megarhyssa* led certain American observers to believe that the larva was entirely lignivorous and not parasitic after all ; and Riley, who quotes this opinion, was constrained to think that the ovipositing female does not seek the host larva, but merely any part of its burrow, along which the young larva wanders till it encounters a victim. We think the very tightly-packed frass would render such wandering impossible.

In any case the extent of this fallibility in *Rhyssa* must materially detract from its efficiency as a parasite of *Sirex*. In this respect, as we shall show, *Ibalia* is superior.

As to how the female *Rhyssa* finds the host larva, we are still almost completely in the dark, as also regarding the exact nature of the antennal sense-organs, which are manifestly the most important instruments in the later stages of the search. We found that after considerable experience we ourselves could select, with a remarkable degree of accuracy, larch trees containing *Sirex* eggs or larvae at a given

* Yet even as recently as 1908, Morley was able to write that it is still a moot point whether *Rhyssa* reaches larvae by intruding its long terebra along the victim's burrow or *in propria persona* bores through bark and solid wood to her prey !

stage of growth. This was accomplished, of course, by considering a number of minutiae of appearance. It seems probable that the female *Rhyssa* is guided, not alone by any hypertrophied single sense, such as olfaction, but by an *ensemble* of sensory cues, including, especially in the preliminary stages of the search, ones of a visual nature.

A large female *Rhyssa*, captured at Tubney on 7th September 1927, was liberated in an insectary of the Farnham Royal Laboratory the next day and well supplied with infested logs. She was without a male and was not observed to oviposit until the 16th, one day after a bred male had been liberated with her. This log was cut open on the 5th October and a *Sirex* burrow found, with a parasitised grub. The part of the tunnel immediately below the puncture was frass-filled, indicating that if the egg had been laid, as seems probable, near the host, the latter had bored further in the meantime. Unfortunately the minutest examination of the frass failed to show any sign of the *Rhyssa* egg-shell; so this point is still not incontrovertibly established. In the present case the nearest part of the burrow, in a more or less perpendicular direction from the oviposition puncture, was 27 mm., which represents the least distance through which the *Rhyssa* must have bored through solid and perfectly sound wood.

In another log in which the same female buried her ovipositor almost to the base (4th October) in two places, the passage was found to lead directly to old frass-filled burrows, abandoned by *Sirex*, of which the adults had emerged during the same season. Again there was no trace of an egg.

It appears indeed that the deposited egg has not yet been observed either of *Rhyssa* or *Megarhyssa*, although Bugnion (1905) describes the ripe eggs dissected from the abdomen of *R. persuasoria*. They are about 12 mm. long, of which 9 make up a narrow pedicel. Since writing this paper we have found eggs, in a number of cases, deposited on various parts of the body of the host larva or pupa. They agree with Bugnion's description but are even longer. As many as three may be laid on a single larva.

The Larva.

So far as our own and previous observations indicate, the larva of *Rhyssa* feeds ectoparasitically from the beginning. The larva which hatched in the insectary, as described above, was 7 mm. long when cut out on 5th October, or 19 days after laying. It was lying upon a full-grown *Sirex* larva, which already looked slightly flaccid. In the splitting of the log, this larva was inadvertently shaken off its host, but, after groping round actively for a few minutes, it regained its hold and continued feeding undisturbed. On 13th October, when the *Rhyssa* larva had attained a length of 9·5 mm., it was transferred with its host to a gelatin capsule. During this process the parasite lost hold a second time, but regained it. On the 17th, the *Rhyssa* was 13 mm. long and the host larva seemed a mere empty skin, though still white and fresh-looking. The former was no longer attached to its prey. On the 22nd, the larva was seen for the first time in three days, when it reached a length of 16 mm. and had finished feeding. It seemed restive. By the 10th November a diaphanous silken cocoon had been spun, just obscuring the transparency of the capsule walls and cutting off from the *Rhyssa* larva, at one end, the shrivelled remains of the *Sirex* grub.

The formation of a more or less complete cocoon, of almost colourless silk, is apparently a constant feature. In the natural burrow it is merely a lining of the walls, and as such may escape notice. One larva, isolated in an elder twig cell, closed with a plug of elder pith, gnawed off pieces of pith to a depth of a millimetre and incorporated the fragments in the fabric at one end.

The larva of *Rhyssa*, which has been described by Miss Checsman and others, resembles closely that of *Megarhyssa* as figured by Riley (Pl. iii, fig. 1). Data on the number of instars are yet to be obtained.

There is a fairly copious black discharge at pupation.

The Pupa.

There is a fairly distinct pre-pupal stage in which the eyes show through the larval integument a faint purple or red. The pupa of *Rhyssa persuasoria* differs markedly from that of *Megarhyssa* in that the elements of the long ovipositor are curved directly backward over the dorsum and only just reach the occiput or in some cases apex of head, whereas in *Megarhyssa* (*Thalessa*) *lunator*, according to Riley's excellent figure, the pupal ovipositor extends caudally for nearly half the length of the body, then curves dorsally, passes round the head, right along the ventral surface, and ends nearly half the body-length behind the tip of the abdomen.

The pupa is at first pure white, the eyes being the first part to darken, and these are black long before any other parts show a trace of colour.

Rhyssa pupae are usually found in terminal burrows which do not appear to differ from those of unparasitised full-fed larvae of the host. They are often separated from the outer world by one centimetre of solid wood, exclusive of bark. The emerging adult excavates through this a passage of smaller calibre than the pupal chamber, with a very neat circular orifice, distinguishable from most of the *Sirex* exit-holes by its smaller size.

The Life-cycle.

The adult *Rhyssa* is most frequent in spring and early summer. It seems to confine its attentions to nearly or quite full-fed *Sirex* larvae or to pupae. Middle-aged grubs would in any case usually be too far in towards the heart of the tree, while younger instars would presumably be too small to nourish a *Rhyssa* larva. Whether the grubs attacked are always in their last summer, or penultimate, or either, is not yet clear. The actual feeding of the *Rhyssa*, assuming the egg laid in the insectary to have hatched within a few days, apparently takes about five weeks. Thereafter the autumn and winter are spent in the resting larval stage, within a cocoon which lines the burrow. Pupation takes place in early spring, and the whole cycle is thus annual. There is some evidence, however, that the larva may continue another year in the resting stage. Of a number (19) of full-fed larvae collected during 1927 and kept inside the laboratory under similar conditions, some have spun cocoons and pupated, and even emerged, while others still remain naked larvae (end March).

Adults and General Notes.

The variation in size is truly remarkable. Our smallest male is only 8·4 mm. long, our largest (S. Devon) 25.7 mm.

No hyperparasites or other natural enemies have been observed.

4. Ibalia leucospoides, Hochenw.

All previous data on the biology of the little-known insects of the subfamily IBALIINAE has been based upon the capture of isolated adults or the rearing of specimens from logs which contained various wood-boring insects. Taschenberg reared a species in large numbers from fir wood heavily infested with *Sirex juvencus*; Drewsen bred both parasite and the suggested hosts—*Sirex juvencus* and *S. noctilio*—from spruce; and Champlain (1922) saw *Ibalia ensiger*, Norton, in Pennsylvania, ovipositing in hemlock, whence he obtained pupae and adults from the cells of *Urocerus*

albicornis. Champlain believed also another American species, *I. maculipennis*, Hald., to be a parasite of *Tremex columba* in hickory. Ashmead (1903) gives most of the earlier American references, and Dalla Torre and Kieffer (1910) summarise the European literature. The most interesting contribution is undoubtedly that of Borries (1891). This observer, working in Denmark, found adults of *Ibalia drewseni*, Bor., still lying in the cells of *Sirex juvencus*. His data were thus hardly more extensive than those of his predecessors, but from a consideration of the habits of this supposed host he suggested a hypothetical life-history which is extraordinarily near the truth. *Ibalia* is active in August, when one finds normally one-year-old *Sirex* grubs fairly near the surface. Borries believed *Ibalia* must therefore oviposit in these, since the length of its ovipositor would not let it reach the older larvae, which at this season are deep in the wood. He thought it must therefore be endoparasitic, and must, from the appearance of the passages he traced, cause the parasitised *Sirex* grub to alter the normal course and to remain in the outer part of the log, finally excavating the pupal cell just under and parallel to the surface. All these suppositions of Borries, except that concerning the age of the host when parasitised, have proved correct.

It will be seen that before the present study the eggs and larval stages of any species of IBALIINAE were unknown.

Oviposition and Egg.

Both *Ibalia* and *Rhyssa* are exceptionally easy to observe while at work. A female *Ibalia* may even be transferred on the fingers from one tree trunk to another, upon which it will continue its search for *Sirex* oviposition-punctures as though no interruption had taken place.

According to our observations, which now number several hundreds, *Ibalia* always oviposits in the borings already made by *Sirex* in its own egg-laying. The extremely fine and hair-like terebra of the *Ibalia* ovipositor thus performs no actual boring—the way is left clear by the host itself. This is only one instance of extremely close co-ordination between the life-processes of *Ibalia* and those of its host.

The " exploration " preliminary to oviposition is extremely detailed. The antennae are bent from near the base at right angles to the long axis of the body, their extreme tips playing like a jet of water on the bark, leaving sometimes not half a square millimetre untouched. Occasionally the tips of the antennae are drawn over the surface with a kind of wiping motion. The wings are flicked slightly and the abdomen jerked up and down a little. Progression is slow. In walking, the long basitarsus of all three pairs of legs, but especially the third, is used like a tibia, only the succeeding tarsal segments ever lying flat on the substratum. Any tiny crack is usually examined with long and particular attention, and one or even both antennae may be inserted into the mouth of a *Sirex* egg-tunnel.

When oviposition is to take place, the abdomen is suddenly and momentarily bent forward and a broad, triangular knife-like structure swung forward from the base of the abdomen, like the blade of a clasp knife. The abdomen and the ovipositor sheath immediately resume their normal position, while from the apex of the " knife-blade " the thread-like ovipositor issues and " feels round," eventually entering the *Sirex* bore. During oviposition the antennae are usually held porrect and immobile. There is a complete absence of that obvious straining which accompanies the actual wood-boring of *Sirex* and *Rhyssa* when egg-laying. The process of oviposition may take upwards of an hour and ten minutes. *Sirex cyaneus* frequently makes egg-bores which are never used for eggs. These sometimes penetrate very slightly, while others are of normal depth. *Ibalia* will insert its ovipositor in these empty holes, and spend 4 to 5 minutes at each, sometimes returning and examining the same ones. Pin-pricks, made to simulate a *Sirex* bore, generally received scant attention ; but one

engaged an *Ibalia* for a minute and a half, during 35 seconds of which the ovipositor was actually inserted.

Ibalia will oviposit in dull weather, or even during light rain, and at times continue this actually till as late as 8.30 in the evening (" summer time " 1st September).

The egg is long and pedunculate, and thus of a general Cynipoid form, though similar also to that of *Rhyssa*. There is, however, this important difference, that in the former, as usual in Cynipids, the body of the egg enters first and the stalk may project from the body of the host, whereas in *Rhyssa*, according to Bugnion, the egg is laid pedicel first.

The egg of *Ibalia* is laid in the young larva just before hatching, or at times possibly in larvae just after hatching. It has been found in almost any part of the body cavity, and there may be two in the same host. *Sirex cyaneus*, more often than not, lays two or three eggs in the same boring, in a linear series, the spaces between and outside being filled with a gelatinous secretion, the source of which has not yet been traced. The female *Ibalia* will lay one egg after another in the same boring. This probably explains the lengthy nature of the process.

That the early development is extremely slow is shown by the occurrence of eggs in young larvae over four or five months after the last adult was seen in the field. It would thus seem that the late-deposited eggs pass the winter in that stage. Earlier eggs, however, seem to hatch in about a month (September).

The Larva.

The first stage larva of *Ibalia* is of an elongate shape, with gigantic sickle-shaped mandibles. As with the egg, there seems no definite localisation in the position of the parasite larva.

No definite information is yet available as to the number of stages. What appears to be a second instar is much longer, rounded anteriorly and tapering gradually caudally, with the sickle-shaped mandibles proportionately much smaller.

The full-fed larva, as usual in wood-boring insects and their parasites, varies considerably in size (Pl. iii, fig. 2). The average is from 12–15 mm. long. The segmentation is strongly marked, the head small and strongly retractile. The whole insect is sometimes so contracted as to appear nearly half as wide as long.

There is no evidence that *Ibalia* feeds ectoparasitically even in the latest stages. Apart from full-fed larvae, lying in empty cells, we have seen none outside the body of the host. Although, as we have seen, more than one egg may be laid in a single host larva, never more than one adult has been found to emerge. At what stage and in what manner one of the competitors is destroyed is not known. Two second (?) instar larvae, each about four-elevenths the length of the host, have been found in one *Sirex* grub.

In a number of cases it has been possible to trace the whole course of a parasitised *Sirex* grub, from the oviposition-bore of the parent to the pupal cell of the *Ibalia*. In every case Borries's observation that the burrowing of a parasitised larva is confined largely to the outer portions of the trunk seemed confirmed. There is also a very considerable shortening of the course, for the host larva is destroyed at a size, and presumably also at an age, much less than it would normally attain ; how much less it is not yet possible to state, since both size and boring activity may be affected by parasitisation.

The Pupa.

In the majority of cases the pupal cell lay just under and parallel to the surface, instead of, as normally, more or less at right angles. Sometimes, however, an *Ibalia* occurred at an angle with the surface, and once a healthy male *Sirex* was found in

a cell just beneath and parallel to the bark. Even when parallel, the *Ibalia* cell was sometimes as much as one centimetre beneath the surface, leaving this thickness of wood and bark to be bored by the emerging adult.

The pupal cell is extremely thinly lined with what appears to be a paste of triturated wood, the fibres of which, under magnification, are seen to be crossed in all directions.

There is a marked pre-pupal stage, as in *Rhyssa*.

The pupa is at first entirely white, the full coloration of the imago appearing during the last ten to twelve days before emergence.

The Life-cycle.

The 1927 season was exceptionally wet and cold, and its data are perhaps not applicable to other years. *Ibalia* was most plentiful in the field during the last week in August and most of September, *i.e.*, just after *Sirex cyaneus* is most active. Unhatched eggs were found as late as 12th December and second (?) instar larvae on 18th January. This, coupled with the finding of full-fed larvae in autumn (*e.g.* November), indicates that the life-cycle, contrary to that of *Rhyssa*, requires at least two years, and possibly longer.

The Adult.

The dead-black thorax, the wings held in vertical plane parallel with the body, and the strongly laterally compressed abdomen, make *Ibalia* very hard to discern on a tree-trunk. Even viewed laterally, the beautiful red sheen of the abdomen, like polished mahogany, is hidden by the smoky wings—save in the virgin female which holds the shining abdomen aloft, above the wings. The sexes are readily distinguished by the shape of the abdomen. In the female the ventral line of the abdomen is apically straight, or even slightly upcurved, and the tip of the ovipositor is just visible. In the male the tip of the abdomen is markedly downcurved.

Like *Rhyssa*, *Ibalia* seems remarkably free from natural enemies. No indications of hyperparasites were seen. Assisted by the length of the process of oviposition, spiders perhaps take a toll of egg-laying females. We thus observed *Amaurobius fenestralis*, Stroem (kindly determined by M. L. Berland) seize an ovipositing *Ibalia* and drag it to a silken tunnel in a crevice under the bark.

Probably in correlation with the fact that the host naturally does not display the greatest variation in size until the later stages *Ibalia* shows considerably less size variation than *Rhyssa*.

Ibalia is usually considered an aberrant Cynipid. Brues, however, believes that " it shows affinities with the SIRICIDAE, upon which it is parasitic."

5. Inter-relations of Rhyssa and Ibalia.

In the attempt to utilise natural enemies in the control of *Sirex*, one of the first questions to be decided is whether both species of parasites should be utilised or only one.

From this point of view, *Ibalia* would seem the more efficient parasite. It attacks the host at an earlier stage, decreasing the extent of its activity; and its method of using the oviposition bores of *Sirex* ensures extremely little ineffectual activity.

Rhyssa, on the other hand, though it kills the host much more rapidly, does so at a later stage, when its boring is nearly completed. Secondly, a great proportion of its time seems to be spent in boring into sites where *Sirex* is absent.

It would appear that *Rhyssa* does not oviposit in larvae young enough to contain *Ibalia* at any stage, so that the risk of superparasitism is probably absent. In these circumstances there can be no objection to utilising both parasites, and this it is proposed to do.

6. The Sirex Position in New Zealand.

The damage by *Sirex* in the pine plantations of New Zealand is due to one introduced steel-blue species which appears to be *Sirex juvencus*, a form now considered merely a variety of *S. noctilio* (Dr. Waterston). When this insect was imported and whence, it is not known, but it came originally probably from Europe. The greatest damage is done to *Pinus radiata*, Don., a native of Western North America. In New Zealand, therefore, both the tree and its pest are living under new conditions, to which Tillyard attributes the extent of the damage inflicted. *Sirex* is said to be attacking healthy trees (Tillyard), but whether this merely implies trees still green and not yet obviously attacked by other insects, though possibly affected by adverse edaphic conditions or fungi (as at Oxford), we have no means of knowing. *Pinus radiata* grows extremely rapidly in New Zealand, and is possibly more susceptible to attack there than in its native home. The position at Oxford is, however, not strikingly dissimilar, since the *Sirex* there is an introduced American species (*S. cyaneus*), and the tree affected (European larch), though indigenous, has been planted. The two parasites are both indigenous, and the fact that they attack *S. cyaneus* so extensively here augurs well for their success in New Zealand against *S. juvencus*.

It remains to state that there is already in New Zealand a large indigenous Rhyssine, *Rhyssa fractinervis*, Voll.,* which, curiously enough, is believed to parasitise the larvae of a large wood-boring weevil, *Rhynchodes ursus*, White (Hudson, Lindsay). *R. fractinervis* is very rare and has no known hyperparasites, and its host bores in dead southern beech trees (*Nothofagus* spp.); so that its occurrence is not likely to affect the present project.

Little seems to have been attempted anywhere in the biological control of forest insects. Yet methods of a more artificial nature are often impracticable. The establishment of the British Ichneumonid, *Mesoleius tenthredinis*, in Canada, as a measure against the larch sawfly, *Nematus erichsoni*, seems to have yielded good results in some localities; the gipsy-moth work in eastern U.S.A. is well-known; and the control of the Australian tree-fern weevil, *Syagrius fulvitarsis*, in Hawaii, by the imported Braconid, *Ischiogonus syagrii*, seems to be largely successful. Few other attempts to utilise the natural enemies of forest insects appear to have been made, though on the Continent, especially in Germany, the beneficial activities of birds and ants in this rôle have long been recognised and, where possible, encouraged.

7. Technique.

The difficulties attendant on the mass collection and rearing of wood-boring insects are so great that a few notes on the methods improvised in the present study may not be out of place.

The main points concern firstly the feeding of the adults—both hosts and parasites—and secondly the safe storage of the full-fed larvae through the very long resting period.

* Dr. Waterston has kindly examined this species and found it to be intermediate in structure between *Megarhyssa* (*Thalessa*) and *Rhyssa*, though it has the general facies of the former. In oviposition (Lindsay) a large bladder near the apex of the abdomen functions as in the former genus.

Large infested larch logs were stood on end on damp sand in a completely-gauzed insectary at Farnham Royal, and the adult insects allowed to fly at will under the vita-glass roof. Mating and oviposition of *Sirex*, *Rhyssa* and *Ibalia* occurred here with facility. One female *Rhyssa* captured on the 7th September lived here for five weeks. A male lived a similar period. In the present year (1928) we have kept one female for over 14 weeks. At the time of capture this female was probably unfertilised, for no attempts at oviposition were observed until the 16th September, one day after a bred male had been liberated in the insectary. Thereafter oviposition continued nearly every day at least until the 4th October. A number of other *Rhyssa*, of both sexes, lived under the same conditions for shorter periods. *Ibalia* adults, usually of unknown age, lived from one to over three and a half weeks. Most of these latter were kept in a large cage in the same insectary.

All parasites were supplied with honey-water and split raisins. *Sirex* was once observed drinking the honey water. *Ibalia* fed constantly at the split raisins, and the favourite food of *Rhyssa* (both sexes) was honey-dew from Aphids on several hawthorn-bushes standing in the same insectary. They also used the honey-water provided and the split raisins.

Full-fed larvae of both *Rhyssa* and *Ibalia* were placed in individual small gelatin capsules, which were lightly pricked at one end and packed in sawdust in metal boxes with close-fitting lids. A piece of blotting-paper projecting from beneath this lid was moistened about once a week in order to prevent dessication, though the atmosphere was never allowed to become sufficiently moist to soften the gelatin capsule or to allow the growth of moulds. *Rhyssa* was found to emerge in a very natural manner from these capsules, by biting a circular hole at one end. It is proposed to ship the parasites to New Zealand in the form of full-fed larvae packed in this manner, thus utilising the long resting stage.

8. Summary.

Rhyssa persuasoria and *Ibalia leucospoides*, both parasitic on *Sirex cyaneus*, have been studied at Oxford.

Rhyssa lays its eggs in the burrow of and near to the almost or quite full-fed host larva or the pupa, by piercing the solid wood with its ovipositor. Feeding is entirely ectoparasitic and takes only a few weeks, during which the host larva may burrow a little further. The winter is passed by *Rhyssa* as a resting larva. Pupation takes place in the spring, and the whole life-cycle normally occupies one year.

Ibalia oviposits in the young larva just before or more rarely just after hatching, utilising the oviposition-bores of the *Sirex* for this purpose. The first-stage larva is elongate, with sickle-shaped mandibles, and larval feeding seems wholly endoparasitic. *Sirex* larvae parasitised by *Ibalia* confine their boring largely to the outer portions of the trunk, and usually make their final cell just under and approximately parallel to the surface. The life-cycle of *Ibalia* requires at least two years.

Owing to the very different instars which they attack, there seems no risk of superparasitism of *Ibalia* by *Rhyssa* or *vice versa*, and it is therefore suggested that both species be introduced into New Zealand as a measure against *Sirex juvencus*, which is there very destructive to plantations of *Pinus radiata*.

Adults of both *Rhyssa* and *Ibalia* may be easily kept in captivity. The former feed readily on honey-dew or honey-water, and the latter on split raisins.

The resting larvae of both may be kept in gelatin capsules packed in sawdust which is not allowed to become entirely dry.

References.

ASHMEAD (W. H.). 1903. Classification of the Gall-wasps and the parasitic Cynipoids of the Superfamily Cynipoidea.—Psyche, Boston, Mass. x, pp. 7–13, 59–73, 140–155, 210–216.

BARBEY (A.) 1925. Traité d'Entomologie forestière. 2nd ed. Paris.

BAUMANN (C.). 1924. Uber den Bau des Abdomens und die Funktion des Legeapparates von *Thalessa leucographa*.—Zool. Anz., Leipzig, lviii, pp. 149–162.

BISCHOFF (H.). 1927. Biologie der Hymenopteren. Berlin.

BORDAS (M. L.). 1917. Du rôle de quelques Ichneumonides comme auxiliaires de l'Arboriculture forestière.—C. R. hebdom. Acad Sci. Fr., Paris, clxiv, pp. 923–925.

BORRIES (H.). 1891. Om Slaegten *Ibalia* Latr.—Ent. Medd., Copenhagen, iii, pp. 53–57.

BRUES (C. T.). 1927. Observations on wood-boring Insects, their Parasites and other associated Insects.—Psyche, Boston, xxxiv, pp. 73–90.

BUGNION (E.). 1905. Les oeufs pédiculés et la tarière de *Rhyssa persuasoria*.—Extr. C.R. 6e Cong. int. de Zool., Sess. de Berne 1904, Geneva, pp. 511–521, 1 pl., 2 figs.

CHAMPLAIN (A. B.). 1922. Records of Hymenopterous Parasites in Pennsylvania.—Psyche, Boston, xxix, pp. 95–100.

CHEESMAN (L. E.). 1922. *Rhyssa persuasoria*: Its Oviposition and Larval Habits.—Proc. S. London Ent. Soc., 1921–22, pp. 1–2.

DALLA TORRE (K. W.) & KIEFFER (J. J.). 1910. Cynipidae: *in* Das Tierreich, Berlin, xxiv, 891 pp.

HUDSON (G. V.). 1927. The Giant Ichneumon-fly, *Rhyssa fractinervis* Voll.—N.Z.Jl. Sci. & Techn., ix, p. 118.

JOHNSON (W. F.). 1919. *Rhyssa persuasoria* in the Counties of Down and Fermanagh.—Irish Naturalist, xxviii, pp. 115–118.

LINDSAY (S.). 1925. The Giant Ichneumon-fly *Rhyssa fractinervis* Voll.—N.Z. Jl. Sci. & Techn., viii, pp. 31–32.

RILEY (C. V.). 1888. The Habits of *Thalessa* and *Tremex*.—Insect Life, i, pp. 168–179, figs. 36–39, 1 pl.

TORKA (V.). 1926. Beobachtungen über die Eiablage von *Sirex spectrum* L. und den Schmarotzer *Rhyssa persuasoria* L. — Anz. Schädlingsk., Berlin, ii, p. 166.

TILLYARD (R. J.). 1927. The Giant Horntail. A Serious Menace to Pine Plantations.—Nelson Evening Mail, 9th Feb. 1927, p. 6.

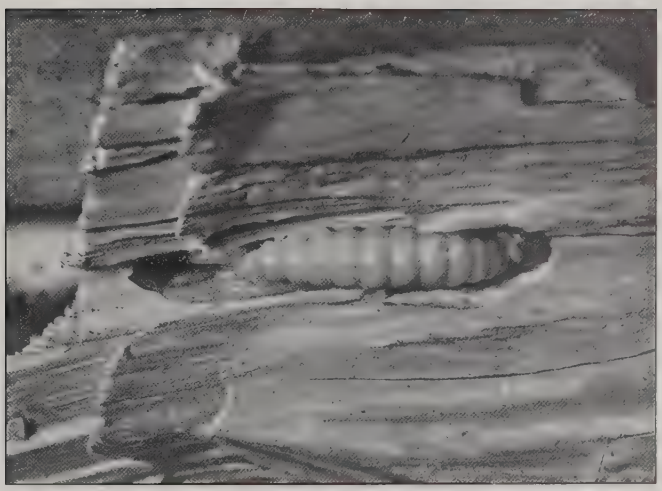

Fig. 1. Larva of *Rhyssa persuasoria*, L., fully fed, lying in a tunnel on the remains of the *Sirex* host.

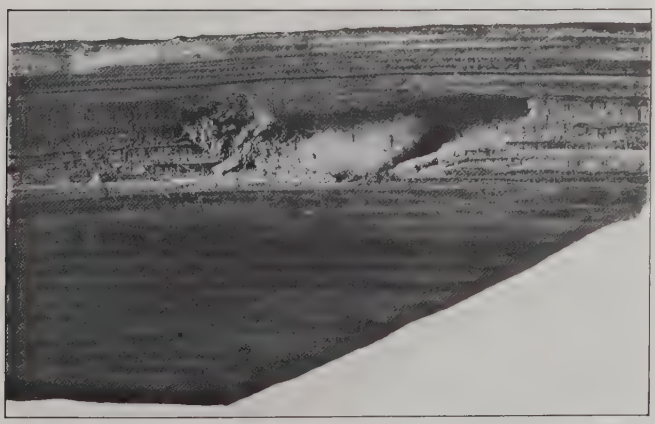

Fig. 2. Larva of *Ibalia leucospoides*, fully fed.

A REVISION OF THE INDO-AUSTRALIAN SPECIES OF THE GENUS *APANTELES* (HYM. BRACON.).—PART I.

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Introduction.

The following paper is intended only as a preliminary revision of this large and exceedingly important group of parasites, and it is the outcome of some six months' work on a small portion of the large mass of material awaiting identification in the collections of the British Museum and of the Imperial Bureau of Entomology. The writer not only has had access to all the types which he required to see that had been deposited in the British Museum, but also was so fortunate as to have been able to arrange with the authorities of both the United States National Museum and the National Hungarian Museum for exchanges of cotypes where sufficiently long series were available, and consequently has been able to examine and include in his key all, or the large majority of, the species that have been described from the Indo-Australian region by Continental and American writers. It should be placed on record that, in addition, the National Hungarian Museum, when not in a position to exchange cotypes, was so good as to forward to the writer on loan the types themselves. With all this extremely kind co-operation, therefore, it has been possible to make this paper tolerably complete; and for purposes of comparison it has been thought desirable to include in the key numerous Palaearctic and Ethiopian species, the types and cotypes of which are to be found in the British Museum.

Some notes with regard to the characters that have been employed in the following paper will not be out of place :—

Colour. This character is used extensively in the key, but only where it seems to be absolutely invariable; where colour is deemed to be variable or unstable in any one species in a group in which this character is constant, the species concerned is placed on both sides of the key.

Wing venation. Venational characters of the forewing only have been used, and where mention is made of any part of the wing it is understood to refer only to the forewing. The venational characters cannot be used for major divisions as they are far from invariable; they are however often extremely useful in the differentiation of one species from another. The nomenclature employed for the parts of the wing is the same as that published by the writer in the Bulletin of Entomological Research, xviii, p. 45.

Punctuation. The strength and density of the punctuation throughout those portions of the integument that have been used in the key and descriptions has been found, except in one instance, to be extremely stable. In dealing with such a small number of species as is treated in this paper, however, it was not found necessary to refer to the punctuation in terms other than broad and generalised, but these have been supplemented to some extent by the use of the numerals one to five; these "degree numbers" refer to the breadth of the punctures rather than to their depth, but should in no instance be taken too literally.

Notauli. Reference is occasionally made to the "lines of the notauli." True notauli are, of course, absent, and it is only intended by this phrase to refer to that portion of the integument where the impressed, converging notauli are more usually found in other genera.

Disc of scutellum. This term is used for the upper portion of the scutellum that is in the same plane as the mesonotum, as differentiated from the *lateral faces of the scutellum.*

Basally above. The hind coxae commonly exhibit at their base a small, flattened area which more rightly should be referred to as the basal antero-dorsal area, but which for the sake of brevity is referred to by the term given above. The punctuation of this area affords a very stable character by which to separate species, and one which as yet only in *glomeratus* has been found to be variable to any really noticeable extent.

First tergite. In the group commencing with the species *taeniaticornis*, namely in the old Ashmeadian genus or subgenus of *Urogaster*, the first tergite in the males is generally to some extent constricted towards the apex, irrespective of the shape of the tergite in the females. This should be borne in mind when reference is made to the figures for this group.

Ovipositor sheaths. In the measurement of these the whole of the *external* portion has been taken. In all the series examined the length of the sheaths relative to the various parts of the hind leg has been found to be absolutely invariable. Where any doubt has arisen, owing to their close approximation in length with a part of the leg, the species concerned has been placed on both sides of the key.

The writer follows Muesebeck (Proc. U.S. Nat. Mus., lviii, pp. 483–576) in entirely disregarding the generic names proposed by Ashmead and Viereck, and utilised to some extent by some subsequent authors; as Muesebeck says, the genus *Apanteles* is not susceptible of division into distinct smaller groups.

In conclusion, it should be remarked that it is earnestly hoped that the various correspondents who have been forwarding specimens of *Apanteles* to the Imperial Bureau will make every endeavour to supplement the meagre series of economic species that have in many instances been sent, and further that they will note that where possible the parasites' cocoons should always be sent with the specimens.

Since this paper is being published in two parts, the key to the species has been placed at the end, thus obviating the necessity for two references for the new species.

1. **Apanteles belippae,** Rohw.

Apanteles belippae, Rohwer, Proc. U.S. Nat. Mus. liv, no. 2249, 1918 (1919), p. 566.

♀♂. Black; hind coxae (except at apex) dark red testaceous to black; apices of hind tibiae and of the joints of the hind tarsi indefinitely brownish; remainder of legs, all sternites, sides of the first three tergites, yellow; mouth-parts, tegulae and costal vein stramineous; stigma and wing veins brown.

♀♂. *Head* more or less generally, and *thorax* with mesothorax posteriorly, mesopleurae anteriorly, scutellum, and propodeon, extremely lightly and sparsely punctate (degree 1), and, apart from the punctures, smooth, polished, and shining, as is most of the integument; mesonotum anteriorly rather more definitely punctured; propodeon without any median carination. *Wings*: 1st abscissa of radial longer than, and sharply angled with, the transverse cubital, which latter is somewhat shorter than the recurrent; 1st abscissa of radial in length about equal to the breath of the stigma, the length of the latter in the female being possibly somewhat longer than the metacarp. *Legs*: the longer hind tibial spur about half, and the shorter spur less than half, the length of the basal joint of the hind tarsus. *Abdomen*: 1st and 2nd tergites (fig. 1, *b*) apparently impunctate, smooth, polished, and shining, except for a few very indefinite punctures on the 1st tergite; ovipositor sheaths about half length of abdomen.

Length: ♀, 3 mm., ♂, 2·5 mm., approximately.

Redescribed from one female cotype and one male cotype presented by Dr. A. B. Gahan, through the Imperial Bureau of Entomology, to the British Museum.

The type locality is given by Rohwer as Bandoeng, Java.

Host: the species originally was "described from 29 females (one, type) and 5 males (one, allotype) reared from larva of *Belippa ohor* by K. W. Dammerman." On the two cotypes that I have seen is a label "ex larva *Belippa lehor*." The Limacodid genus of *Nemeta*, Walk., under which *Belippa*, Walk., has now been synonymised by van Eecke in "Lepidopterorum Catalogus," 1925, has the species *lohor* Moore, which is undoubtedly the name that was intended.

Cocoons unknown.

This is the only species that I have seen from the Oriental region that has the long ovipositor of the old genus, or subgenus, *Urogaster*, together with the propodeon and 2nd tergite of *Apanteles* in the old restricted sense.

2. Apanteles agamemnonis, sp. n.

♀♂. Head except mouth-parts, thorax, apical tergites above, sheaths of ovipositor, black; all legs except as below, mouth-parts, tegulae, costal vein, 1st abdominal segment completely, 2nd segment (except medianly above), 3rd segment (except largely above), clear shining red testaceous; antennae variable, commonly opaque testaceous basally to reddish brown, nigrescent towards apex; stigma and apical third of hind tibiae brown; basal segment of hind tarsi, and wing veins (except as above), brownish.

♀♂. *Head*, and *thorax* with the mesonotum, mesopleurae anteriorly, scutellum, and propodeon, sparsely and extremely lightly punctuate, virtually impunctate (degree 1), otherwise smooth, and shining and polished; propodeon without any median carination. *Wings*: 1st abscissa of radial longer than, and sharply angled with, the transverse cubital, which latter is somewhat longer than the recurrent; length of the 1st abscissa of radial equal to the breadth of the stigma, the length of the latter being somewhat less than that of the metacarp. *Legs*: the longer hind tibial spur fully two-thirds, and the shorter spur not more than half, the length of the basal joint of the hind tarsus. *Abdomen*: tergites extremely sparsely and lightly punctate, on the 1st tergite only towards apex; otherwise all tergites smooth, polished, and shining; the impressed lines on the 2nd tergite (fig. 1, *a*) broadly divergent, rather indefinitely marked, shallow, narrow, short, and slightly curved; the 2nd tergite often with a few extremely weak, diverging striae more towards the middle; 3rd tergite hardly longer than the 2nd; ovipositor sheaths very short.

Length, 2·5 mm.

MALAYA: Kuala Lumpur, 5 ♀♀, 12♂♂, and 2 with the abdomen missing, 27. xii. 1924 (*G. H. Corbett*).

Type deposited in the British Museum.

Host. Recorded by Mr. Corbett as bred from *Papilio agamemnon*, Linn.

Cocoons unknown.

3. Apanteles papilionis, Vier.

Apanteles (*Protapanteles*) *papilionis*, Viereck, Proc. U. S. Nat. Mus., xlii, no. 1888, 1912, p. 145.

Agrees very well with the description of *A. agamemnonis*, sp.n., except as follows:—

♀♂. Apical fourth of hind tibiae, hind tarsi, tegulae, and costal vein, brownish; 1st tergite nearly stramineous; 2nd tergite in the female largely like the 1st, in the male almost completely darkened; 3rd and succeeding tergites completely darkened; antennae with flagellum and apex of scape dark brown to black throughout.

♀♂. *Thorax*: mesonotum anteriorly, and scutellum, definitely more strongly punctate (degree 2); 2nd tergite with the impressed lines not widely divergent, and broader, deeper, and somewhat shorter than in *A. agamemnonis*.

Length, 3 mm.

Redescribed from one female and one male in the British Museum, which were determined by Mr. Muesebeck.

The type locality is recorded as Mysore, India.

Hosts. The type series was bred from larvae of the Papilionid, *Papilio polytes*, L.; the paratypes were received from Bangalore, from larvae of *P. demoleus*, L.; Mr. Rohwer (Treubia, iii, 1922, p. 53) also records having received *A. papilionis* from Mr. Leefmans, who stated that he reared this insect at Buitenzorg, Java, from larvae of *P. sarpedon*, L.; the specimens of *Apanteles* in the British Museum were bred by Mr. T. J. Anderson, Government Entomologist, Kenya Colony, East Africa, from a Papilionid, "probably *P. demodocus*, Esp."

Cocoons unknown.

4. Apanteles obliquae, sp. n.

♀♂. Agrees in colour with my redescription of *A. creatonoti*, Vier., except as follows:—Hind coxae black; flagellum entirely dark brown; apical fourth of the 1st tergite black.

♀♂. Agrees well enough in sculpture with my redescription of *A. creatonoti*, except as follows:—*Wings*: the venation variable, but the point of junction of the 1st abscissa of the radial with the transverse cubital always apparent; length of the 1st abscissa of the radial equal to the breadth of the stigma, longer than the transverse cubital, which latter equals the recurrent, *or*, the length of the transverse cubital equal to the breadth of the stigma, with the 1st abscissa of the radial equal to the recurrent; the recurrent much longer than the apical portion of the 1st abscissa of the cubital, which is much longer than the pigmented portion of the 2nd abscissa, this latter being about equal to the upper portion of the basal vein; stigma shorter than metacarp. *Legs*: hind coxae basally above and outer faces entirely smooth and impunctate. *Abdomen*: 1st tergite (fig. 1,*f*) with some ill-defined punctures and sculpture in the apical quarter.

Length, ♀ rather less than 3 mm., ♂ 2 mm.

India: Nilambur, Madras, 11 ♀♀, 3 ♂♂, 12. ix. 1925 (*S. N. Chatterjee*).

Type deposited in the British Museum.

Host. Recorded as parasitic on the Arctiid moth, *Diacrisia obliqua confusa*, Butl.

Cocoons unknown.

Apanteles obliquae var. **niger**, nov.

♀♂. Separable from the typical series only on the following somewhat variable colour differences:—1st tergite almost entirely black, or at least extremely dark red basally with the apical half black; all coxae largely darkened to black.

India: Dehra Dun, United Provinces, 6 ♀♀, 2 ♂♂, 2. xii. 1927 (*S. N. Chatterjee*).

Type deposited in the British Museum.

Host. Recorded as bred from cocoons taken from under the bark of *Tectona grandis*; probably therefore parasitic on *Diacrisia obliqua confusa*, Butl.

5. Apanteles creatonoti, Vier.

Apanteles (*Protapanteles*) *creatonoti*, Viereck, Proc. U.S. Nat. Mus., xlii, no. 1888, 1912, p. 144.

♀♂. Black; legs (except apical third of hind tibiae, and hind tarsi, which are darkened), mouth-parts, scape, flagellum below basally, tegulae, most ventrites, 1st tergite (except at extreme apex, which is black), 3rd tergite laterally, lateral membranous margins of the two basal tergites, red testaceous; palpi and tibial spurs pale; stigma and wing veins brown.

♀♂. *Head*: face punctate (degree 2). *Thorax*: mesonotum with strong well-separated punctures (degree 3 and 4), more sparsely and finely punctate posteriorly; disc of scutellum very finely, sparsely, and indefinitely punctate (degree 1); propodeon smooth and shining discally and possibly slightly excavate, laterally towards base with strong well separated punctures (degree 4), in apical half with fine carinae converging on a median apical point. *Wings*: 1st abscissa of radial and the transverse cubital evenly rounded, their point of junction consequently indeterminable; the apical portion of the 1st abscissa of the cubital definitely much shorter than the recurrent, longer than the upper portion of the basal vein, which latter is longer than the pigmented portion of the 2nd abscissa of the cubital; stigma shorter than metacarp. *Legs*: hind coxae with the outer faces above, and basally above, entirely smooth, very highly polished and shining; the longer hind tibial spur two-thirds, and the shorter spur less than half, the length of the basal joint of the hind tarsus. *Abdomen*: 1st tergite (fig. 1, *h*) with a few well-defined punctures (degree 3–4) towards apex; ovipositor sheaths longer than the long hind tibial spur.

Length, ♀ rather less than 3 mm., ♂ about 2·5 mm.

Redescribed from 6 ♀♀, 1 ♂, Sardong, Malaya, 24. iv. 1925 (*G. H. Corbett*). Specimens of this series, now in the British Museum, were compared by Dr. A. B. Gahan with the type series of *A. creatonoti*, and he pronounced them to be that species.

The type locality was given as Honalli, Mysore, India.

Hosts. The type series was bred from the Arctiid moth, *Creatonotus albistriga*, Walk.; Corbett's series is labelled "ex (?) *Creatonotus transiens*, Walk."

Cocoons unknown.

6. Apanteles erionotae, sp. n.

♀♂. Black; legs (except for the coxae, which are largely black, and for the apices of the hind femora and of the hind tibiae, which are strongly darkened), scape, flagellum largely below in basal half (otherwise red brown), the 2nd and 3rd tergites, and basal ventrites, red testaceous; palpi and tibial spurs pale; 1st tergite black or deep red-black; stigma and wing veins brown.

The four front coxae are commonly largely red testaceous, and so are sometimes the hind coxae below apically, while in the Sumatran series the 2nd and 3rd tergites are largely darkened.

♀♂. *Head*: face punctate (degree 2-3), the punctures rather indefinite. *Thorax*: mesonotum with strong, well-separated punctures (degree 5); disc of scutellum with some definite, very widely separated, strong, but often extremely shallow, punctures (degree 5), apparently often largely impunctate; propodeon with well marked, median, longitudinal carina, from which on each side oblique carinae run upwards and join a strong transverse basal carina; the oblique carinae are strong in the Malayan series but are also often more or less effaced, and in the Sumatran series they are commonly obsolete. *Wings*: the breadth of the stigma definitely less than the length of the 1st abscissa of the radial, definitely greater than the length of the recurrent, which latter is longer than the transverse cubital; the apical portion of the 1st abscissa of the cubital equal to the pigmented portion of the

2nd abscissa, definitely shorter than the transverse cubital, less than half the breadth of the stigma; stigma shorter than metacarp. *Legs*: hind coxae basally above with strong, well-separated punctures (degree 5), on outer faces with numerous, widely spaced, strong punctures (degree 3-4); the longer hind tibial spur 2/3, and the shorter spur rather more than 1/2, the length of the basal joint of the hind tarsus. *Abdomen*: 1st tergite (fig. 1, *d*) highly polished and shining, in the apical half with strong, well-separated punctures (degree 3-4); 2nd tergite shining and virtually unsculptured, with the usual impressed lines evident only at the extreme base; ovipositor sheaths short.

Length: Malayan series, 3 mm.; Sumatran series, 2·25 mm.

MALAYA: Parit Buntar, 3 ♀♀ (one the type), 2 specimens of unknown sex, iii. 1922 (*G. H. Corbett*). SUMATRA: Deli, East Coast, 12 ♀♀, 13 ♂♂, 26.i.1926.

Type deposited in the British Museum.

Host. Both series are recorded as bred from the Hesperiid butterfly, *Erionota thrax*, L.

Cocoons unknown.

Dr. Gahan, to whom I showed these two series, agrees with me that they are not separable on the single stable character that we were able to find, namely the size.

7. Apanteles aristolochiae, sp. n.

♀. Black; legs (except hind tarsi and apices of hind tibiae, which are darkened somewhat), scape, tegulae, mouth-parts, ventrites mostly, and lateral membranous margins of the three basal tergites, red testaceous to light yellow-red testaceous; flagellum red-brown; stigma and wing veins brown.

The hind coxae are sometimes more or less dark red basally.

♀. *Head*, and *thorax* with the mesonotum, disc of scutellum, and propodeon, finely and evenly punctate (degree 1); the propodeon without any further sculpture. *Wings*: 1st abscissa of the radial rather shorter than the breadth of the stigma, angled with and definitely longer than the transverse cubital, which latter about equals the recurrent in length; the apical portion of the 1st abscissa of the cubital about equal to the pigmented portion of the 2nd abscissa of the cubital, definitely shorter than the recurrent, about equal to or rather longer than the upper portion of the basal vein; stigma equal to or just shorter than metacarp. *Legs*: hind coxae finely punctate; the longer hind tibial spur 3/5, and the shorter spur somewhat less than 1/2, the length of the basal joint of the hind tarsus. *Abdomen*: 1st and 2nd tergites closely approximating in shape to those of *A. artonae* (fig. 1,*c*), apparently impunctate, except possibly along extreme lateral margins somewhat; ovipositor sheaths about equal in length to the longer hind tibial spur.

Length, 2·5 mm.

CEYLON: Peradeniya, 4 ♀♀, 24.ii.1919 (*J. C. Hutson*).

Type deposited in the British Museum.

Host. Recorded as bred from the larva of *Papilio aristolochiae*, F.

Cocoons unknown.

The lateral sulci of the 2nd tergite are more widely divergent than, and not so closely placed basally, nor so broadly and deeply impressed as, in *A. artonae*; they are, also, possibly slightly curved.

8. Apanteles badgleyi, sp. n.

♀. Agrees in colour with my description of *A. aristolochiae*, except that the hind coxae are never darkened basally.

♀. *Head*, and *thorax* with the mesonotum and disc of scutellum, finely punctate (degree 1-2); propodeon with numerous fine carinae and numerous well-marked, separated punctures (degree 3), with no definite median longitudinal or transverse basal carinae. *Wings*: my description for the wings of *A. aristolochiae* agrees very

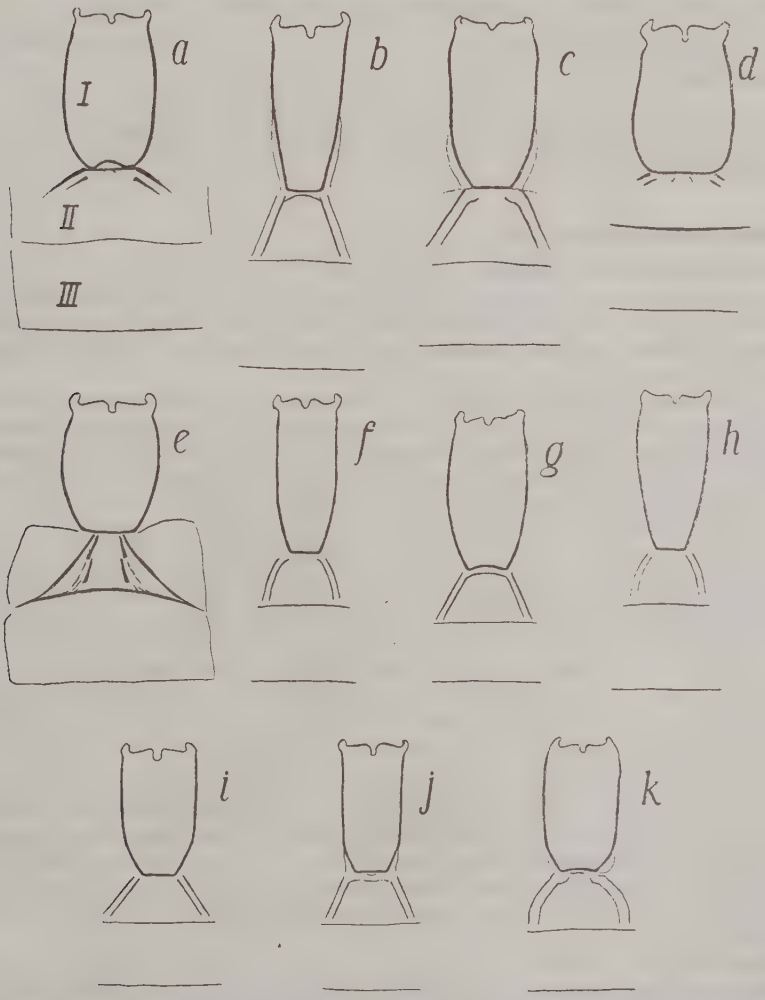

Fig. 1. First, second and third tergites of: (*a*) *A. agamemnonis*; (*b*) *A. belippae*; (*c*) *A. artonae*; (*d*) *A. erionotae*; (*e*) *A. acherontiae*; (*f*) *A. obliquae*; (*g*) *A. lamprosemae* (*h*) *A. creatonoti*; (*i*) *A. bataviensis*; (*j*) *A. phytometrae*; (*k*) *A. taylori*. (×50)

well, except that the stigma is definitely shorter than the metacarp. *Legs*: hind coxae apparently more or less closely punctate throughout (degree 2); the longer hind tibial spur 3/5, and the shorter spur 1/2, the length of the basal joint of the hind tarsus. *Abdomen*: 1st and 2nd tergites in shape extremely like those of *A. belippae*,

noticeably punctate or punctate aciculate in apical half (degree 3-4); 2nd tergite usually with a few extremely fine striae towards the lateral sulci; ovipositor sheaths about equal to the longer hind tibial spur.

Length, nearly 3 mm.

Assam: 8 ♀♀, and 2 of indeterminable sex, undated (*W. F. Badgley*).

Type in the British Museum.

Host unknown.

Cocoons white; they are contained within a more or less spherical mass of white fluff about the size of a raspberry, the breadth of this mass nowhere more than 15 mm. or less than 12 mm.

9. **Apanteles acherontiae**, Cam.

Apanteles acherontiae, Cameron, Spol. Zeylan., v, pt. 17, 1907, p. 17.

♀♂. Black; legs (except coxae and trochanters), scape, mouth-parts, costal vein, red testaceous; the apices of the hind tibiae and of each joint of the hind tarsi possibly somewhat darkened; stigma, metacarp, radial and transverse cubital, dark brown, remaining veins pale.

♀♂. *Head* finely punctate (degree 1). *Thorax*: mesonotum laterally posteriorly with well-separated shallow but well-marked punctuation (degree 4 about), anteriorly and medianly more closely set and smaller; disc of scutellum with scattered weak punctures, often more noticeably punctate (degree 2-3) in apical half; propodeon smooth, polished, and shining, virtually unsculptured except for some weak aciculations medianly at apex. *Wings*: 1st abscissa of radial about equal to the breadth of the stigma, roundly angled with and a little longer than the transverse cubital, but their point of junction rather hard to determine; the recurrent about equal to the transverse cubital; the upper portion of the basal vein shorter than the recurrent, longer than the apical portion of the 1st abscissa of the cubital, which latter is subequal to, or possibly a shade longer than, the pigmented portion of the 2nd abscissa of the cubital; stigma about equal to or even possibly longer than metacarp. *Legs*: hind coxae finely punctate (degree 1), basally above with a group of more definite punctures (degree 3); hind tibial spurs virtually subequal, and about half length of basal joint of hind tarsus. *Abdomen*: 1st tergite (fig. 1,*e*) strongly sculptured (punctate, or rugoso-punctate, or even apparently sometimes with aciculations also) all round the apical margins; the area of the 2nd tergite that is enclosed by the impressed sulci is very small, seemingly at apex not as broad as the apex of the 1st tergite; there are however large lateral areas, which are each larger than the median enclosed area, and the impressed sulci extend in reality in a wide sweep to the external apical corners of these lateral areas, the true apex of the 2nd tergite being much broader than the 1st tergite at its greatest breadth; ovipositor sheaths about as long as a hind tibial spur.

Length, 2·5 mm.

Redescribed from Cameron's four "types," and from 2♀♀, 2♂♂, undated (*J. C. Hutson*), which are labelled as bred in Ceylon from the same host as the type series, and from 6 ♀♀, 22.xii.1914 (*A. Rutherford*), recorded as bred from *Acherontia* sp., also from Peradeniya, Ceylon.

The type locality is given as Peradeniya, Ceylon.

Host: a larva of the Sphingid moth, *Acherontia lachesis*, F. Muesebeck (J. Bombay N.H. Soc. xxxi, 1926, p. 726) also records it from larvae of *Acherontia styx*, Westw.

Cocoons. The pupae of *A. acherontiae* are spun together in a large white cottony mass. This mass has been well described by Cameron (*loc. cit.*), by E. E. Green (Spol. Zeylan., *t.c.*, p. 19, with a plate), and also by McCann (J. Bombay N.H. Soc. xxxi, p. 727, with plate).

10. Apanteles ashmeadi, nom. n.

Glyptapanteles manilae, Ashmead, Proc. U.S. Nat. Mus., xxviii, no. 1387, 1904 (1905), p. 147 (nec *Apanteles manilae*, Ashm. 1904).

♀. Black ; legs (except coxae), basal ventrites, lateral membranous margins of the basal tergites, scape largely, red testaceous ; the apex of the hind tibiae, and the hind tarsi, darkened slightly ; palpi pale ; flagellum dark red-black, redder beneath ; tegulae and costal vein testaceous ; stigma and wing veins brown.

♀. *Head*, and *thorax* with the mesonotum and disc of scutellum, more or less finely punctate (degree 1) ; propodeon apparently impunctate, shining, unsculptured save for a definite elongate shallow median longitudinal excavation. *Wings* : 1st abscissa of the radial about equal to or rather less than the breadth of the stigma, roundly angled with and rather longer than the transverse cubital, which latter is about equal to the recurrent ; the apical portion of the 1st abscissa of the cubital shorter than the recurrent, but longer than the pigmented portion of the 2nd abscissa of the cubital, which latter about equals the upper portion of the basal vein ; stigma shorter than metacarp. *Legs* : hind coxae above completely smooth and impunctate ; the longer hind tibial spur half, and the shorter spur two-fifths, the length of the basal joint of the hind tarsus. *Abdomen* : 1st and 2nd tergites apparently closely approximating in shape to those of *A. artonae* (fig. 1, *c*) ; 1st tergite apparently very finely and sparsely punctate round the margins of the apical quarter ; ovipositor sheaths as long as the longer hind tibial spur.

Length, rather less than 2·5 mm.

Redescribed from a single female specimen determined by Dr. Gahan and presented by him, through the Imperial Bureau of Entomology, to the British Museum.

The type locality is given by Ashmead as Manila.

Host unknown.

Cocoons unknown.

11. Apanteles colemani, Vier.

Apanteles (*Protapanteles*) *colemani*, Viereck, Proc. U.S. Nat. Mus., xlii, no. 1888, 1912, p. 143.

♀. Black ; legs (except coxae) and basal ventrites red testaceous ; antennae and stigma dark brown ; wing veins pale to colourless.

♀. *Head* finely punctate (degree 1). *Thorax* : mesonotum, disc of scutellum, and propodeon, indefinitely and obscurely punctate (degree 1 about) ; propodeon otherwise unsculptured except in the lateral apical corners, where it is indefinitely sculptured. *Wings* : 1st abscissa of radial and the transverse cubital more or less evenly rounded, their point of junction more or less indeterminable ; the recurrent longer than the apical portion of the 1st abscissa of the cubital, this latter longer than the upper portion of the basal vein, which again is longer than the pigmented portion of the 2nd abscissa of the cubital ; stigma shorter than metacarp. *Legs* : the hind coxae apparently obscurely punctate on outer faces ; the longer hind tibial spur rather longer than half, and the shorter spur rather less than half, the length of the basal joint of the hind tarsus. *Abdomen* : 1st and 2nd tergites in shape much as

those of *A. bataviensis* (fig. 1, *i*); 1st tergite apparently punctate and setiferous all along lateral margins, and obscurely so at apex, otherwise smooth; ovipositor sheaths about as long as the shorter hind tibial spur.

Length, rather more than 2 mm.

Redescribed from a female cotype presented by Dr. A. B. Gahan, through the Imperial Bureau of Entomology, to the British Museum.

The type locality is given as Vegati, Mysore, India.

Host. Larvae of the Liparid moth, *Orgyia postica*, Walk.

Cocoons unknown.

12. Apanteles bataviensis, Rohw.

Apanteles (*Protapanteles*) *bataviensis*, Rohwer, Proc. U.S. Nat. Mus., liv, no. 2249, 1918 (1919), p. 566.

♀♂. Black; legs (except coxae, which are black to dark red-black, and except hind tibiae in apical third, and hind tarsi largely, which are nigrescent), costal vein, and basal ventrites, red testaceous; scape largely, and flagellum largely on underside, red testaceous, brown otherwise; palpi pale; stigma brown; wing veins light brown to pale or colourless.

♀♂. *Head* finely punctate (degree 1). *Thorax*: mesonotum and disc of scutellum finely punctate (degree 2–3); propodeon very commonly but not always with scattered, sparse, but definite punctuation (degree 2–3). *Wings*: the point of junction of the 1st abscissa of the radial with the transverse cubital normally more or less indeterminable; the upper portion of the basal vein long, often as long as the recurrent, and always as long as or longer than the apical portion of the 1st abscissa of the cubital, which latter is longer than the pigmented portion of the 2nd abscissa of the cubital; stigma rather shorter than metacarp. *Legs*: hind coxae on outer faces above highly shining and virtually impunctate, above towards base commonly with one or two deep elongate excisions; the longer hind tibial spur two-thirds, and the shorter spur half, the length of the basal joint of the hind tarsus. *Abdomen*: 1st tergite (fig. 1, *i*) indefinitely punctate at extreme apex, otherwise entirely highly polished and shining; ovipositor sheaths apparently about as long as the longer hind tibial spur.

Length, 2·5 mm.

Redescribed from one female and one male cotype presented by Dr. A. B. Gahan, through the Imperial Bureau of Entomology, to the British Museum, and from a long series of more than sixty females and males bred by Dr. Karny in Buitenzorg, Java, from the same host as the type series.

The type locality is given as Batavia, Java.

Host: the Lasiocampid moth, *Odonestis* (now *Paralebeda*) *plagifera*, Walk.

Cocoons. We are in possession of the host larva from which Dr. Karny bred his long series. The parasitic cocoons are placed close together and erect all over the body of the larva; they are so numerous and they so closely cover the host as to give to it almost the appearance of a caddis-fly larval case.

A. bataviensis is readily separable from *A. colemani* by the colour of the hind tibiae and hind tarsi, by the nature of the punctuation on the 1st tergite, and by the relative lengths of the upper portion of the basal vein; the elongate upper portion of the basal vein is a character absolutely constant in the series of *bataviensis* before me.

13. Apanteles lamprosemae, sp. n.

♀♂. Black; legs (except coxae, which are black, and except about apical half of hind tibiae, and hind tarsi largely, which are strongly nigrescent or darkened) and

costal vein red testaceous; basal ventrites and tegulae strongly reddened; palpi and hind tibial spurs pale; antennae red, paler beneath; stigma and metacarp dark brown, other veins paler brown.

The lateral membranous margins of the 1st and 2nd tergites, and even the 3rd tergite itself, are commonly reddened or red testaceous.

♀♂. *Head* finely punctate (degree 1). *Thorax*: mesonotum weakly but distinctly punctate (degree 2–3), the punctures even and separate; disc of scutellum indefinitely punctate (degree 1–2); propodeon very largely smooth and shining, with some well-marked but more or less weak carinae at apex medianly (more rarely at sides of apex, where the propodeon is more commonly somewhat indefinitely sculptured), and commonly with a few well-marked punctures (degree 3 and 4), these punctures often more or less entirely wanting. *Wings*: 1st abscissa of radial and the transverse cubital evenly rounded, their point of junction indeterminable; the upper portion of the basal vein definitely shorter than the recurrent, about as long as or even possibly sometimes rather longer than the apical portion of the 1st abscissa of the cubital, which latter is always definitely longer than the pigmented portion of the 2nd abscissa of the cubital; stigma shorter than metacarp. *Legs*: the longer hind tibial spur about two-thirds, and the shorter spur half, the length of the basal joint of the hind tarsus; hind coxae above on outer faces impunctate except for a few well marked punctures (degree 3) above, dully shining, elsewhere closely and finely punctate (degree 1–2). *Abdomen*: 1st tergite (fig. 1, *g*) highly shining, definitely punctate (degree 2–3) along the lateral quarters of the apical half; ovipositor-sheaths normally equal in length to the shorter hind tibial spur, but apparently might be exserted so as to become as long as or longer than the longer hind tibial spur.

Length, ♀, 2·5 mm., ♂, about 2 mm.

MALAYA: Kuala Lumpur, 5 ♀♀, 3 ♂♂, 16.ii.1925 (*G. H. Corbett*).

Type deposited in the British Museum.

Host. Recorded as bred from the Pyralid moth, *Lamprosema diemenalis*, Guér.

Cocoons. The larvae apparently do not pupate in a gregarious mass. The cocoons are 3 mm. long, white, and very thinly spun.

14. Apanteles puera, sp. n.

♀♂. Black; the four front legs, the hind legs (except the coxae which are entirely black, the apical one-third of the tibiae and the apex of each tarsal joint, and the extreme apices of the femora sometimes, which are nigrescent), basal ventrites and scape somewhat, red testaceous; flagellum very dark brown; palpi pale; tegulae testaceous; stigma and wing veins brown; the lateral membranous margins of the three basal tergites more or less dark red testaceous.

♀♂. *Head* finely punctate (degree 1.) *Thorax*: mesonotum finely punctate, somewhat more strongly and closely so anteriorly (degree 1 or 2); disc of scutellum largely highly polished and shining, with some fine punctures; propodeon rather sparsely, but definitely and evenly, punctate (degree 2 to 3), otherwise without sculpture or carination. *Wings*: length of 1st abscissa of radial equal to the breadth of the stigma, usually longer than and always definitely angled with the transverse cubital, which latter about equals the recurrent; apical portion of the 1st abscissa of the cubital equal to the pigmented portion of the 2nd abscissa of the cubital, as long as or longer than the upper portion of the basal vein, definitely shorter than the recurrent; stigma shorter than metacarp. *Legs*: hind coxae at least finely punctate, basally above with well marked punctures (degree 3) which often coalesce to form elongated impressions; the longer hind tibial spur about half or rather more than half, and the shorter spur less than half, the length of the basal joint of the hind tarsus. *Abdomen*: 1st tergite in shape much like that of *A. phytometrae* (fig. 1, *j*), sparsely

punctate along sides and in apical half (degree 3), occasionally somewhat aciculate instead of punctate ; 2nd tergite with the lateral sulci straight and widely divergent, more widely than in *phytometrae*, much as in *bataviensis* (fig. 1, *i*) ; succeeding tergites with but a few scattered, fine punctures ; ovipositor sheaths as long as or longer than the longer hind tibial spur.

Length, 2·5 mm.

INDIA : Bengal, Chittagong Hill Tracts, Kaptai, 4 ♀♀, 6 ♂♂, 24.xi.1926 (*S. N. Chatterjee*).

Type deposited in the British Museum.

Host. Recorded as parasitic on the larvae of the Noctuid, *Hyblaea puera*, Cram.

Cocoons solitary and apparently white ; they are of stout, parchment-like texture, and are 3 mm. long.

15. Apanteles lamborni, sp. n.

♀♂. Black ; scape, the four anterior legs entirely, the hind legs (except the coxae, which are for the greater part black, but somewhat testaceous at apex below, and except for the apical third of the tibiae and the whole of the tarsi, which are nigrescent), basal ventrites, lateral membranous margins of the 1st and 2nd tergites, the 3rd tergite normally entirely, red testaceous ; palpi pale ; flagellum red-brown to red testaceous below basally, apically dark brown ; tegulae testaceous ; stigma and wing veins brown ; wings very slightly infumate.

♀♂. *Head* finely punctate (degree 1). *Thorax* : mesonotum finely and evenly punctate (degree 1–2) ; disc of scutellum highly polished and shining, with some punctures (degree 2) particularly basally along margins, virtually impunctate ; propodeon virtually devoid of any carinae or rugosity, with scattered, sparse, but fairly evenly spaced, punctuation (degree 1–2) ; the extent and degree of the punctuation on both the scutellum and the propodeon is extremely variable, often being hardly apparent on the propodeon. *Wings* : the 1st abscissa of the radial equal to the breadth of the stigma, just longer than the transverse cubital, which latter is about equal to the recurrent ; the point of junction of the 1st abscissa of the radial with the transverse cubital is not always clearly deliminated, these veins sometimes being more or less definitely angled, and sometimes rounded, and the relative length of the transverse cubital is rather variable ; the apical portion of the 1st abscissa of the cubital equal in length to the pigmented portion of the 2nd abscissa of the cubital, these being decidedly shorter than the upper portion of the basal vein, which latter is shorter than the recurrent ; stigma if anything rather shorter than metacarp. *Legs* : hind coxae finely punctate (degree 1, or possibly 2) apparently throughout ; the longer hind tibial spur three-fifths, and the shorter spur two-fifths or one-third, the length of the basal joint of the hind tarsus. *Abdomen* : 1st and 2nd tergites in shape hardly differing from those of *A. creatonoti* (fig. 1, *h*), except that they are possibly just a little shorter and a little stouter, definitely somewhat sparsely punctate (degree 2) in apical half, particularly towards sides, at sides almost rugose ; 2nd tergite with the impressed bounding sulci so strongly curved downwards as almost to be parallel with each other apically ; ovipositor sheaths well exserted, as long as the longer hind tibial spur.

Length, 2·5 mm.

FEDERATED MALAY STATES : Ulu Gombak, 17 ♀♀, 6 ♂♂, 20.xii.1920 (*Dr. W. A. Lamborn*).

Type deposited in the British Museum.

Host. Recorded as bred from a (?) Lycaenid larva.

Cocoons unknown.

16. Apanteles philippinensis, Ashm.

Apanteles philippinensis, Ashmead, J.N.Y. Ent. Soc., xii, 1904, p. 19 (nec *Urogaster philippinensis*, Ashm. 1904).

♀. Dark red; thorax black; the four anterior legs (except the coxae), hind tibiae basally, basal ventrites, lateral membranous margins of the 1st and 2nd tergites, yellow; palpi and hind tibial spurs white; stigma and wing veins tawny.

♀. Agrees in sculpture apparently with my description of *A. phytometrae*.

Redescribed from one female cotype presented by Dr. A. B. Gahan, through the Imperial Bureau of Entomology, to the British Museum. The ♂ is unknown.

The type locality is given by Ashmead as Manila.

Host unknown.

Cocoons unknown.

This species would appear to differ from *phytometrae* on account of its red coxae and yellow front legs. It is possible that the specimen before me is immature, especially as Ashmead, in his inadequate description of the eight specimens from which he described this species, says that the antennae are wholly black, and implies that the coxae are black. Ashmead, however, states that the length of his species is 1·5 to 1·6 mm., whereas the cotype before me is more than 2 mm.; I have therefore ignored his description and have separated out *A. philippinensis* entirely on colour characters, so that it may possibly prove to be the same as my species *phytometrae*.

17. Apanteles phytometrae, sp. n.

♀♂. Agrees apparently absolutely with my description of *A. corbetti*, both in colour and sculpture, except that the lateral bounding sulci of the 2nd tergite (fig. 1, *j*) are straight.

Samoan Is.: 25 ♀♀ (one the type), 7 ♂♂, and 8 specimens of sex indeterminable either through damage or indifferent mounting, undated (*P. A. Buxton* and *G. H. Hopkins*). Sumatra: East Coast, Deli, 7 ♀♀, 2 ♂♂, xii. 1924.

Type deposited in the British Museum.

Host. Dr. Buxton records that the Samoan series was bred from the Noctuid, *Phytometra chalcites*, Esp., on cucumber, etc. (his serial No. 717); the Samoan series, however, also contains two specimens (serial No. 720) labelled "*ex* Plusia sp. pest of Tomato." The Sumatran series is recorded from larvae of *Phytometra* (*Plusia*) *signata*.

Cocoons white, 3 mm. long, not very stoutly made, and grouped loosely together, after the style of *glomeratus*.

18. Apanteles corbetti, sp. n.

♀♂. Black; palpi, the four anterior legs (except their coxae and trochanters), basal half of hind tibiae, basal joint of hind tarsi at extreme base, basal ventrites, lateral membranous margins of the 1st and 2nd tergites, light red- to yellow-testaceous; hind femora, apical half of hind tibiae, remainder of hind tarsi, tegulae, antennae, stigma, metacarp, red brown to dark red brown.

♀♂. Agrees in sculpture with my redescription of *A. artonae* except as follows: mesonotum sparsely and finely punctate (degree 2); propodeon largely smooth basally, rarely, if ever, with even weak indications of any oblique ridge; 1st tergite in shape as in *phytometrae* (fig. 1, *j*), indefinitely sculptured in apical fourth; 2nd tergite with the lateral sulci slightly but definitely curved much as in *taylori* (fig. 1, *k*).

Length, rather more than 2 mm.

MALAYA: Kuala Lumpur, 9 ♀♀, 1 ♂, 28.iv.1925 (*G. H. Corbett*).

Type deposited in the British Museum.

Host. Recorded as bred from a Geometrid on brinjal (Corbett's No. 2400)

Cocoons unknown.

19. Apanteles nigrescens, Cam.

Protapanteles nigrescens, Cameron, J. Bombay Nat. Hist. Soc., xvii, 1906, p. 102.

♀. Black; all tibiae and tarsi strongly nigrescent, except that the extreme bases of the four hind tibiae are pale, as are the tibial spurs and the palpi; stigma and wing veins light brown.

♀. *Head* finely punctate (degree 1). *Thorax*: mesonotum damaged by pin; disc of scutellum finely punctate (degree 1); propodeon very largely smooth, with some indefinite sculpture. *Wings*: the transverse cubital nearly as long as the breadth of the stigma, very definitely longer than the 1st abscissa of the radial, somewhat longer than the recurrent; the apical portion of the 1st abscissa of the cubital about equal in length to the 1st abscissa of the radial; stigma longer than metacarp. *Legs*: hind coxae apparently finely punctate throughout; the longer hind tibial spur rather longer than half the length of the basal joint of the hind tarsus. *Abdomen*: 1st and 2nd tergites in shape approaching that of those of *A. creatonoti* (fig. 1, *h*), except that the 1st tergite is shorter, relatively broader basally, and more pointed at apex, and that the 2nd tergite is virtually triangular, the impressed converging lateral bounding sulci almost touching each other at the base; 1st tergite apparently impunctate; 2nd and succeeding tergites apparently finely punctate (degree 1); ovipositor sheaths shorter than the longer hind tibial spurs.

Length, rather more than 2 mm.

Redescribed from Cameron's type, which is in the British Museum.

The type locality was given as Quetta, India.

Host unknown.

Cocoons unknown.

20. Apanteles artonae, Rohw.

Apanteles artonae, Rohwer, Proc. Ent. Soc. Wash., xxviii, 1926, p. 188.

♀♂. Deep red-brown to black; palpi, hind tibial spurs, and basal ventrites, pale; front legs (except coxae, trochanters and generally basal third of femora), middle legs distally generally from about middle of femora, and basal fourth of hind tibiae, red testaceous; wing veins (except metacarp) brown.

♀♂. *Head* finely punctate (degree 1–2). *Thorax*: mesonotum with well marked, but rather shallow, well separated punctures, more strongly punctate anteriorly than posteriorly (degree 3–4); disc of scutellum finely and sparsely punctate (degree 1); propodeon almost entirely, more or less indefinitely sculptured or rugose, definitely without a median longitudinal carina, but often medianly in about basal half somewhat lightly and broadly excavate and smooth, almost invariably with indications and often strong indications of a carina or ridge extending on each side obliquely from the neighbourhood of the basal lateral corners to the middle and apex of the propodeon, often so strongly marked as to give the impression of an incipient broad areola not basally closed. *Wings*: 1st abscissa of the radial and the transverse cubital evenly curved, their point of junction hardly discernible; the upper portion of the basal vein, the apical portion of the 1st abscissa of the cubital, and the recurrent, all about equal, the latter possibly usually somewhat the longest, but very definitely shorter than the transverse cubital; stigma shorter than metacarp. *Legs*: hind coxae with

the whole outer face above impunctate and dully shining, with the inner face regularly and separately punctate (degree 2), below very closely punctate or rugulose; the longer hind tibial spur just longer than half, and the shorter spur one-third, the length of the basal joint of hind tarsus. *Abdomen*: 1st tergite (fig. 1, *c*) closely punctate (degree 3) along the broad margins of the apical half; 2nd tergite with its lateral bounding sulci straight; 2nd and succeeding tergites smooth and shining except for a few very weak scattered punctures; ovipositor sheaths about as long as the longer hind tibial spur.

Length, 2 mm.

Redescribed from a male and female cotype, and from 8 ♀♀, 2 ♂♂, from Java, 1926 (*T. N. C. Taylor*).

The type locality was given as Kuala Lumpur, Federated Malay States.

Host. Mr. Taylor's specimens were bred from the Zygaenid, *Artona catoxantha*, Hamps., at various elevations from sea-level up to 2,000 ft., above which height neither host nor parasite appears normally to occur (cp. *A. taylori*). The type series was recorded as parasitic on the early stages of *Artona catoxantha*.

Cocoons unknown.

It is further recorded that efforts are being made to introduce this species of *Apanteles* into Fiji, to control the Zygaenid, *Levuana iridescens*, B.-Bkr.

21. Apanteles taylori, sp. n.

♀. Agrees in colour with my redescription of *A. artonae*, Rohw., except that the four anterior femora are hardly so much darkened.

♀. Agrees in sculpture with my re-description of *A. artonae*, except as follows: in the wings the recurrent is always noticeably longer than the apical portion of the 1st abscissa of the cubital, possibly even as long as the transverse cubital; 2nd tergite (fig. 1, *k*), with its lateral bounding sulci slightly but definitely curved.

JAVA: Mt. Gede, 5 ♀♀, 1926 (*T. N. C. Taylor*).

Type deposited in the British Museum.

Host. This species is recorded by Mr. Taylor as bred from the Zygaenid, *Artona albicilia*, Hamps.; he says further that it appears to be confined to this host and that it occurs at an altitude of from 2,000 to 5,000 ft., rarely if ever below (cp. *A. artonae*).

Cocoons unknown.

22. Apanteles flavipes, Cam.

Cotesia flavipes, Cameron, Mem. Proc. Manch. Phil. Soc., (4) iv, 1891, p. 185.
Apanteles (*Stenopleura*) *nonagriae*, Viereck, Proc. U.S. Nat. Mus., xliv, 1913, p. 645.
Apanteles (*Stenopleura*) *simplicis*, Viereck, l.c.

♀♂. Black; legs, antennae, mouth-parts, and basal ventrites, red testaceous; stigma and wing veins mostly brown; tegulae and costal vein testaceous; tergites (except basal two) commonly very dark red-black.

♀♂. *Head* largely impunctate, smooth, polished, and shining; face weakly but definitely punctate (degree 1–2); antennae of females submoniliform, short, not as long as body, of males normal, longer than body. *Thorax* compressed, wider between tegulae than deep dorso-ventrally; mesonotum with strong, unusually well separated, and comparatively sparse punctuation (degree 3–4), more densely punctate anteriorly; otherwise mesonotum absolutely smooth, polished, and shining, as are the disc of the scutellum, and the mesopleurae, except that the latter have a few punctures anteriorly (degree 3); propodeon evenly rugulose. *Wings*: length of the transverse cubital and of the recurrent each about equal to the breadth of the stigma, and

definitely longer than the 1st abscissa of the radial, which is about equal to the apical portion of the 1st abscissa of the cubital, which latter is a little shorter than the pigmented portion of the 2nd abscissa of the cubital ; stigma shorter than metacarp. *Legs* : hind coxae at least at base above with well separated punctures (degree 3–4) ; hind tibial spurs subequal, hardly half as long as the basal joint of the hind tarsus. *Abdomen* : 1st and 2nd tergites (fig. 2, *e*) longitudinally rugulose, succeeding tergites smooth, polished, shining, and impunctate ; ovipositor sheaths short.

Length, 2–2·5 mm.

Redescribed from Cameron's unique type (which is a male and not a female) ; from 10 ♀♀, 15 ♂♂, received from Pusa, India ; and from one female cotype each of *A. nonagriae* and *A. simplicis*, both of which were presented by Dr. A. B. Gahan, through the Imperial Bureau of Entomology, to the British Museum.

Type in British Museum.

Host. As Cameron states, his type was bred at Poona, India, from a larva attacking *Sorghum vulgare*. This larva was subsequently shown to be a species belonging to the Pyralid genus *Chilo* (Indian Museum Notes, i, p.29 ; iii, p. 52 ; and v, pp. 21 and 65), a species now well known as *Chilo simplex*, Butl. The long series that I received from Pusa was likewise bred from *Chilo simplex*. This species also is given as the host of *A. simplicis*, the type locality of which is Taihoku, Formosa. The host of *A. nonagriae* is given as the Noctuid, *Sesamia* (*Nonagria*) *inferens*, Walk., with type locality Taihoku, Formosa.

Cocoons unknown.

A. nonagriae and *A. simplicis* are not separable. The apically broad 2nd tergite of the former, a character on which alone Viereck apparently relies to separate these species, is not apparent in the cotype in front of me. Dr. Gahan, in his MS. on the Oriental species of *Apanteles* that are in the U.S. National Museum, also synonymises these species ; Cameron's species was not known to him .

See *A. nonagriae*, Olliff.

23. **Apanteles chilocida,** Vier.

Apanteles (*Stenopleura*) *chilocida*, Viereck, Proc. U.S. Nat. Mus., xliii, 1913, p. 582.

I have not seen this species, but I have been enabled to place it in its position through the kindness of Dr. Gahan, who lent me the MS. of his key to the Oriental species of *Apanteles* that are in the U.S. National Museum.

This is a species extremely close to *A. flavipes*, Cam., apparently differing from this latter only in the colour of the hind coxae, which in *chilocida* are " blackish." Dr. Gahan suggests that *chilocida*, *nonagriae*, and *simplicis* are all synonymous.

The type locality of *A. chilocida* is given as Japan.

Host. The type was labelled *Chilo simplex.*

Cocoons unknown.

24. **Apanteles ruidus,** sp. n.

♀♂. Black ; antennae, tegulae, and stigma, dark brown to black ; hind tarsi brown ; wing veins light brown ; mouth-parts and tibial spurs stramineous ; legs otherwise red testaceous, except for the coxae which are black, and for the extreme apices or even sometimes the apical third of the hind tibiae which are darkened slightly, and for the hind femora, which are commonly strongly tipped with black ; basal ventrites testaceous.

♀♂. *Head* very lightly but rather closely punctate (degree 1) ; face with a weak but definite median longitudinal ridge. *Thorax* : mesonotum medianly, posteriorly rugose-punctate (degree 3), anteriorly as strongly but not so closely punctate ; laterally, the punctures separated and finer (degree 1 and 2) ; scutellum with some broad shallow punctures ; propodeon broadly rugose with shining areas between the rugae, with median longitudinal and transverse basal carinae of varying strength. *Wings* : 1st abscissa of radial about equal to the stigma in breadth, possibly a little longer than the recurrent, which latter is obviously longer than the transverse cubital ; stigma shorter than the metacarp. *Legs* with the hind coxae basally above with a small area of fairly close, strong, more or less aciculate punctures (degree 3), elsewhere smooth and shining with some scattered strong punctures ; hind tibial spurs subequal, about half the length of basal joint of hind tarsus. *Abdomen* : 1st and 2nd tergites (fig. 2, *h*) rugose, the 3rd at least basally, and commonly completely, rugulose, each succeeding tergite with a transverse row of minute punctures; ovipositor sheaths in length about equal to or rather longer than the hind tibial spurs.

Length, 2–2·5 mm.

INDIA : Rahatgaon, Hoshangabad, Central Provinces, 52 ♀♀, 27 ♂♂, 26.ix.1926–5.i.1927 (*S. N. Chatterjee*).

Type deposited in the British Museum.

Host. Recorded by Beeson as parasitic on the Pyralid, *Pyrausta machaeralis*, Walk.

Cocoons solitary, white, and stoutly constructed.

The rugosity on the 3rd tergite does not always extend to the apex ; the extreme apex, particularly towards the lateral margins, is commonly smooth.

25. Apanteles antipoda, Ashm.

Apanteles antipoda, Ashmead, Proc. Linn. Soc. N.S.Wales, xxv, 1900, p. 355.
Apanteles manilae, Ashmead, J.N.Y. Ent. Soc., xii, 1904, p. 19 (nec *Glyptapanteles manilae*, Ashm. 1905).
Apanteles sydneyensis, Cameron, Proc. Linn. Soc. N.S. Wales, xxxvi, 1911, p. 342.
Apanteles (*Protapanteles*) *narangae*, Viereck, Proc. U.S. Nat. Mus., xliv, no. 1974, 1913, p. 642.

♀♂. Black ; legs except hind coxae, tegulae, red testaceous ; apices of hind femora and of hind tibiae just slightly nigrescent ; hind tarsi slightly browned ; antennae reddish brown ; stigma and wing veins light brown ; basal ventrites usually testaceous ; 3rd and succeeding tergites dark red.

♀♂. *Head* minutely punctate (degree 1), shining. *Thorax* : mesonotum particularly in posterior half coarsely and closely punctate (degree 5), the punctures so close as to form almost a reticulate appearance ; laterally the mesonotum is considerably smoother ; disc of scutellum strongly punctate (degree 5), the punctures mostly separated ; propleurae largely, mesopleurae anteriorly and wholly below, sternum wholly, rugoso-punctate and dull ; mesopleurae posteriorly above entirely smooth and shining ; propodeon rugose. *Wings* : 1st abscissa of radial normally equal in length to the transverse cubital (often, however, rather shorter), rather shorter than the recurrent, definitely shorter than the breadth of the stigma, longer than the apical portion of the 1st abscissa of the cubital ; stigma possibly shorter than the metacarp. *Legs* : hind coxae largely rugulose and dull ; hind tibial spurs of about equal length and about half the length of basal joint of hind tarsus. *Abdomen* : 1st and 2nd tergites rugulose, in shape agreeing absolutely with those of *A. taprobanae* (fig. 2, *a*), except that those of *antipoda* are somewhat smaller and

that its 2nd tergite has strong indications of lateral sulci ; remaining tergites smooth, shining, and virtually impunctate ; ovipositor sheaths well exserted but not longer than the hind tibial spurs.

Length, about 2 mm.

Redescribed from a male and a female cotype of *antipoda*, a male cotype of *manilae*, a female cotype of *narangae*, all presented by Dr. A. B. Gahan, through the Imperial Bureau of Entomology, to the British Museum ; from Cameron's four female " types " of *sydneyensis* ; from 5 ♂♂, 2 ♀♀, and 2 of indeterminable sex, Dehra Dun, United Provinces, India, iv. 1916 (*C. F. C. Beeson*) ; from 6 ♀♀ 3 ♂♂, and one of indeterminable sex, Dehra Dun, United Provinces, India, x.1926 (*D. J. Atkinson*) ; from 7 ♀♀, 2 ♂♂, Pusa, India, 24.iii.1919 (*D. P. Singh*) ; and from 10 ♀♀, Pusa, India, 13.i.1926 (*R. Saran*).

The type locality of *antipoda* is given as Sydney, New South Wales, that of *manilae* as Manila, that of *sydneyensis* as Sydney, and that of *narangae* as Taihoku, Formosa.

Hosts. The host of *antipoda* was recorded as a species of the Noctuid genus *Agrotis* ; there were no host records for *manilae* and *sydneyensis* ; *narangae* was recorded from the Noctuid, *Naranga diffusa*, Walk. ; Beeson's series is recorded as parasitic on the Pyralid, *Hypsipyla robusta*, Moore ; Atkinson's series was bred from some insect on sal (*Shorea robusta*) ; Singh's series is labelled as parasitic on the Noctuid, *Perigea capensis*, Guen. In addition I have seen a series of 45 ♀♀ (5.vii. 1921, *Dr. J. C. Hutson*) which had been bred in Ceylon from larvae of the Noctuid, *Spodoptera mauritia*, Boisd.

Cocoons. The cocoons of *narangae* are stated to be yellowish brown, and to be arranged obliquely in rows on blades of grass ; the cocoons of the numerous Indian specimens were unfortunately not forwarded ; those of *sydneyensis* are white.

It was Dr. Gahan who suggested to me that *narangae* and *manilae* were synonyms of *antipoda* ; the slight differences in colour that are noticeable between these insects seem to be due to immaturity.

26. **Apanteles philoeampus**, Cam.

Apanteles philoeampus Cameron, Proc. Linn. Soc. N.S. Wales, xxxvi, 1911, p. 342 (nec *A. philocampus*, Cam., Timehri, (3) i, 1911, p. 327).

♀. Black ; legs, except coxae, red testaceous ; about apical half of hind tibiae, and hind tarsi, darkened ; palpi and hind tibial spurs stramineous ; costal vein basally testaceous ; tegulae, wing veins, and stigma, brown ; basal ventrites testaceous.

♀. *Head* very faintly punctate (degree 1). *Thorax* : mesonotum rather indefinitely punctate (degree 2–3), rugoso-punctate along the line of the notauli ; disc of scutellum virtually impunctate ; propodeon lightly rugose, with strong indications of a median longitudinal carina and of transverse basal carinae. *Wings* : transverse cubital definitely longer than the 1st abscissa of the radial, with a strong stump at their point of junction ; recurrent about equal to the transverse cubital, longer than the apical portion of the 1st abscissa of the cubital, shorter than the breadth of the stigma; stigma rather longer than metacarp. *Legs* : the longer hind tibial spur just half the length of basal joint of hind tarsus, the shorter spur a little shorter ; hind coxae indefinitely punctate. *Abdomen* : 1st tergite in apical fourth, and 2nd tergite, lightly rugose ; 1st tergite broader at apex than at base, with its sides straight, about 1½ times as long as broad at apex ; 2nd tergite broader than apex of 1st ; 3rd and succeeding tergites impunctate, highly polished and shining ; 3rd tergite longer than 2nd ; ovipositor sheaths well exserted but definitely shorter than two-thirds basal joint of hind tarsus.

Length, 3 mm.

Redescribed from Cameron's two female specimens, which are on one card with one type label.

Type in British Museum.

The type locality was given as Wattle Flat, New South Wales.

Host unrecorded, except that the specimens were " bred from a caterpillar."

Cocoons unknown.

A difference is noticeable between the two specimens in the strength of the 1st abscissa of the radial and the transverse cubital ; in one specimen these veins are decidedly more slender.

27. Apanteles pratapae, Ashm.

Apanteles pratapae, Ashmead, Proc. U.S. Nat. Mus., xviii, no. 1092, 1896, p. 647.

♀. Black ; scape, legs, 2nd and all succeeding abdominal segments, red testaceous, the prosternum and the hind coxae darker ; 1st tergite dark red ; mouth-parts pale ; stigma and wing veins brown ; tegulae testaceous.

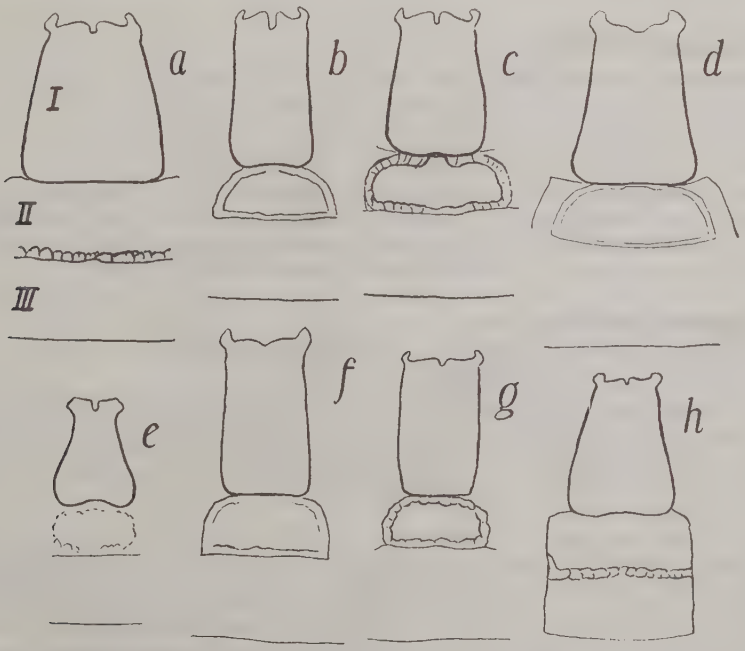

Fig. 2. First, second and third tergites of : (*a*) *A. taprobanae* ; (*b*) *A. tiracholae* ; (*c*) *A. effrenus* ; (*d*) *A. rufiventris* ; (*e*) *A. flavipes* ; (*f*) *A. cheesmanae* ; (*g*) *A. anthelae* ; (*h*) *A. ruidus*. (×50)

♀. *Head* and face virtually entirely covered with strong, well and evenly separated, punctures (degree 5). *Thorax* : prosternum, mesonotum, mesopleurae anteriorly, punctate like the head, the disc of the scutellum as strongly but decidedly more sparsely punctate ; propodeon with a large median basal area, which becomes narrower as it approaches the apex, rugose, or possibly more rightly describable as punctate-reticulate ; the apical lateral areas smooth and shining ; propodeon outside

the lateral carinae strongly punctate near base of hind coxae. *Wings*: 1st abscissa of radial longer than, and well angled with, the transverse cubital, which latter is about equal to the recurrent; pigmented portion of the 2nd abscissa of the cubital as long as the apical portion of the 1st abscissa; stigma as broad as the length of the 1st abscissa of the radial, shorter than metacarp. *Legs*: hind coxae above basally punctate like the head; the longer hind tibial spur two-thirds, and the shorter spur half, the length of the basal joint of the hind tarsus. *Abdomen*: 1st tergite in shape extremely like that of *A. anthelae* (fig. 2, *g*), strongly punctate in apical half (degree 5); 2nd tergite towards base indefinitely aciculate punctate; succeeding tergites apparently unsculptured; ovipositor sheaths not longer than basal joint of hind tarsus.

Length, 2·5 mm.

Redescribed from one female cotype presented by Dr. A. B. Gahan, through the Imperial Bureau of Entomology, to the British Museum.

The type locality is given as Pundaluoya, Ceylon.

Host. This species was bred from a larva of the Lycaenid, *Pratapa deva*, Moore.

Cocoons unknown.

28. Apanteles glomeratus, L.

Ichneumon glomeratus, Linné, Syst. Nat., ed. 10, 1758, p. 568.

India: Dehra Dun, United Provinces, 20 ♀♀, 10 ♂♂, 20.xii.1927 (*C. F. C. Beeson*); 4 ♀♀, 2 ♂♂, 14.iv.1925 (*G. D. Bhasin*).

Host: the Pierid, *Pieris brassicae*, L.

The Indian specimens of this well known species of *Apanteles* appear to differ slightly from typical European specimens, but not sufficiently, in the opinion of Mr. G. T. Lyle, to whom the above series was submitted, to warrant their separation even under a racial name. I have not seen the cocoons of the Indian form.

29. Apanteles paludicolae, Cam.

Apanteles paludicolae, Cameron, Spol. Zeylan., vi, 1909, p. 41.
Apanteles platyptiliae, Cameron, l.c.

♀♂. Black; legs (except coxae, which are black) varying from completely red testaceous to red testaceous with the four anterior femora very dark in basal half, and the hind femora darkened to black, and the apical third of hind tibiae darkened; basal ventrites red testaceous; palpi and tibial spurs pale; costal veins testaceous; tegulae, stigma, and most wing veins, brown.

♀♂. *Head* finely punctate (degree 1). *Thorax*: mesonotum with more or less extremely fine and coalescent punctuation (degree 1–2); disc of scutellum with possibly some extremely weak and shallow punctures; propodeon with strong, median longitudinal, and transverse basal, carinae, largely broadly rugose with the intermediate areas shining. *Wings*: 1st abscissa of radial and the recurrent about equal in length, shorter than the breadth of the stigma, longer than the transverse cubital, which latter is longer than the apical portion of the 1st abscissa of the cubital; stigma shorter than metacarp. *Legs*: hind coxae very finely punctate; hind tibial spurs subequal, about half, or rather less than half, the length of the basal joint of the hind tarsus. *Abdomen*: 1st tergite in shape much as that of *A. glomeratus*, the apical half rugose; 2nd tergite rugulose, with the lateral bounding sulci well marked (but not deep), rounded, and evenly impressed to apex of the tergite; ovipositor sheaths about half the length of basal joint of hind tarsus.

Length, 2·0–2·5 mm.

Redescribed from Cameron's 3 ♀♀ " types," and from one specimen of indeterminable sex of *paludicolae*,and from a male and female of *platyptiliae* both labelled as " type."

Types in the British Museum.

The type locality of *paludicolae* is given as Diyatalawa, 4,000 ft., Ceylon, and of *platyptiliae* as Madulsema, Ceylon.

Hosts. *A. paludicolae* is recorded as bred from the Pterophorid, *Trichoptilus paludicola*, Fletcher, a species now known under the name of *paludum*, Zell. ; *A. platyptiliae* is recorded as a parasite of the larvae of the Pterophorid, *Platyptilia molopias*, Meyr.

Cocoons. Those of *paludicolae* are white and are placed longitudinally along thin stems.

30. Apanteles australiensis, Ashm.

Apanteles australiensis, Ashmead, Proc. Linn. Soc. N.S. Wales, xxv, 1900, p. 356.

♀. Black ; legs (except coxae), tegulae largely, red testaceous ; palpi and basal ventrites pale ; stigma and wing veins brown. The extreme apices of the hind femora and of the hind tibiae and the whole of the hind tarsi are darkened slightly.

♀. *Head* finely punctate. *Thorax* : mesonotum posteriorly and along the lines of the notauli with strong, separated punctures (degree 5) ; disc of scutellum with a few scattered, extremely shallow punctures, mostly smooth and shining ; propodeon at extreme base smooth and with a short, median, longitudinal carina, at least apical three-quarters rugose and dull, with no transverse basal ridge. *Wings* : 1st abscissa of radial in length less than the breadth of the stigma, longer than the recurrent ; transverse cubital and the recurrent equal in length, just a little longer than the apical portion of the 1st abscissa of the cubital ; stigma rather longer than metacarp. *Legs* : hind coxae with a few strong punctures above, the lateral faces with some fine punctures (degree 1), largely impunctate, smooth, and shining ; the longer hind tibial spur rather less than two-thirds, and the shorter spur rather less than one-half, the length of the basal joint of the hind tarsus. *Abdomen* : 1st tergite in shape much as that of *A. cheesmanae* (fig. 2,*f*), except that it is possibly slightly broader throughout, about apical two-fifths with strong, well separated punctures, remainder smooth and shining ; 2nd tergite longer than fourth, but shorter than 3rd tergite, indefinitely sculptured or roughened, with margins indefinitely deliminated, hardly broader than the 1st tergite ; 3rd and succeeding tergites with only a few fine punctures (degree 1), virtually entirely smooth and shining ; ovipositor sheaths not longer than the shorter hind tibial spur.

Length, 3·5 mm.

Redescribed from one female cotype presented by Dr. A. B. Gahan, through the Imperial Bureau of Entomology, to the British Museum.

The type locality is given as Australia.

Host unrecorded.

Cocoons unknown.

31. Apanteles deliadis, Bingh.

Apanteles deliadis, Bingham, Trans. Ent. Soc. Lond., 1906, p. 125.

♀♂. Agrees in colour with *A. australiensis* except that the tegulae are darker, that the scape is largely red testaceous, that the flagellum basally below is more or less red testaceous, and that the hind legs are not so strongly darkened.

♀♂. Agrees with my redescription of *A. australiensis* except as follows:—*Thorax*: punctures on mesonotum not so strong (degree 4); propodeon entirely broadly rugose with intermediate shining areae and with the median longitudinal carina more or less complete. *Wings*: length of 1st abscissa of radial equal to breadth of stigma; transverse cubital and the apical portion of the 1st abscissa of the cubital equal in length, very slightly shorter than the recurrent, which is decidedly shorter than the 1st abscissa of the radial; stigma about equal to metacarp. *Legs*: hind coxae with lateral faces sparsely punctate (degree 2); hind tibial spurs apparently subequal and apparently somewhat longer than half the basal joint of hind tarsus. *Abdomen*: 2nd tergite with its apical and lateral bounding sulci more or less well marked, in shape much as that of *A. cheesmanae*, only not so broad relatively to the 1st tergite, rather smoother than in *A. australiensis*.

Length, 3 mm.

Redescribed from a male and a female cotype in the British Museum.

The type locality is Townsville, North Queensland, Australia.

Host: the Pierid, *Delias argenthona*, F.

Cocoons unrecorded.

32. **Apanteles taprobanae,** Cam.

Apanteles taprobanae, Cameron, Mem. Proc. Manch. Phil. Soc., xli, 1897, no. 4, p. 38.

Apanteles (*Protapanteles*) *stauropi*, Viereck, Proc. U.S. Nat. Mus., xlii, no. 1888, 1912, p. 146.

Apanteles (*Protapanteles*) *formosae*, Viereck, op. cit., xliv, no. 1974, 1913, p. 642.

♀♂. Black; scape largely, flagellum below basally, legs (except coxae), ventrites, median tergites along the lateral margins, red testaceous; flagellum above and apically, stigma and metacarp, brown; costal vein testaceous; hind tarsi slightly darkened; palpi and tibial spurs pale; abdomen towards apex commonly completely darkened.

Varies in colour in the extent of the red testaceous marking along the lateral margins of the median tergites.

♀♂. *Head*: face punctate (degree 2). *Thorax*: mesonotum with strong, well separated, possibly rather shallow, punctures (degree 3–4); disc of scutellum indefinitely sculptured and indefinitely punctate; propodeon with a definite, median, longitudinal carina, from which on each side oblique carinae run upwards and join a strong transverse basal carina. *Wings*: in the specimens before me the breadth of the stigma, and the length of the transverse cubital, and of the recurrent, all about equal, definitely shorter than the 1st abscissa of the radial, definitely greater than the apical portion of the 1st abscissa of the cubital, rather more than twice as long as the pigmented portion of the 2nd abscissa of the cubital, which latter is longer than the upper portion of the basal vein; the relative lengths of the 1st abscissa of the radial and the transverse cubital are variable, so that the latter is often nearly equal to the former. *Legs*: hind coxae shining, basally above with strong, definitely separated punctures (degree 4), on outer faces also strongly punctate but more weakly (degree 3–4) and more sparsely; the hind tibial spurs equal, about half the length of the basal joint of the hind tarsus. *Abdomen*: 1st tergite (fig. 2,*a*) in apical half rugoso-punctate, the punctures nearly always strong (degree 4), the rugae variable in extent and strength so that the tergite sometimes appears only to be punctate; 2nd tergite lightly and indefinitely sculptured, occasionally with some definite punctures, definitely without lateral sulci; ovipositor sheaths short.

Length, about 2·75 mm.

Redescribed from the type of *A. taprobanae*, which is in the British Museum (two specimens on one card, agreeing with one another absolutely); from one female cotype of both *P. stauropi* and *P. formosae*, these two latter presented by Dr. A. B. Gahan, through the Imperial Bureau of Entomology, to the British Museum; and from 29 ♀♀, 3 ♂♂, ix. 1922 (*R. Menzel*), and 12 ♀♀, 4 ♂♂, 22. viii. 1924 (*R. Menzel*), from Java.

The type locality of *taprobanae* was given by Cameron as Trincomali, Ceylon; the type locality of *stauropi* is Bangalore, Mysore, India, and that of *formosae*, Taihoku, Formosa.

Host. Cameron gave no host record for *taprobanae*; *stauropi* was bred from larvae of the Notodontid, *Stauropus alternus*, Walk.; the host of *formosae* was thought to be a Notodontid larva; the first and longer of the Javan series was bred by Dr. Menzel from *Stauropus alternus* on tea.

Cocoons. Those of the Javan series are white and are heaped indescriminately together on the twigs of the plant.

The sculpture, in the Javan series, of the 1st and 2nd tergites is, almost without exception, considerably stronger than that of Cameron's *taprobanae*. The range of variation in the strength of this sculpture however is sufficiently marked to warrant, in my opinion, the assertion that in this species the sculpture of this portion of the integument cannot be used even in the differentiation of races. If this is accepted, the Javan series is correctly named as *taprobanae*, as there is no other character by which one may separate these two. By the same token therefore *formosae* immediately falls as a synonym of *stauropi*, and there is no doubt in my own mind that this latter is synonymous with *taprobanae*, since the only character that I can find to separate them is one that is unstable, namely the relative lengths of the 1st abscissa of the radial and the transverse cubital.

I would remark, finally, that Viereck also noted that the strength of the sculpture on these tergites seemed to be variable.

33. Apanteles cheesmanae, sp. n.

♀♂. Black; the four anterior legs (except their coxae, which are slightly nigrescent), the hind legs (except coxae, at least apical third of femora, apical third of tibiae, tarsi), palpi, tegulae, three or four basal ventrites, the lateral membranous margins of the 1st and 2nd tergites, the 3rd tergite, testaceous to red-testaceous; stigma and wing veins dark brown; wings apparently evenly infuscated throughout.

The colour of the hind legs, of the four anterior coxae, and of the 3rd tergite, is variable. There are dark forms in which the hind femora are almost entirely nigrescent to black, the hind tibiae black on apical half, 3rd tergite (except for lateral margins) completely black, and four anterior coxae strongly nigrescent.

♂♀. *Head* finely punctate (degree 1); face with a short definite, median, longitudinal ridge in upper third. *Thorax*: mesonotum posteriorly, medianly with strong, separated punctures (degree 4), laterally indefinitely punctate, anteriorly closely but lightly punctate (degree 2 about); punctures on the disc of the scutellum extremely shallow; propodeon broadly rugose throughout, with median longitudinal and transverse basal carinae just noticeable. *Wings*: breadth of stigma about equal to or just less than length of 1st abscissa of radial, this latter being somewhat longer than, and more or less evenly rounded with, the transverse cubital, this latter again rather less than the recurrent but just longer than the apical portion of the 1st abscissa of the cubital; stigma shorter than metacarp. *Legs*: hind coxae with more or less weak (degree 2–3), separated, rather sparse, punctuation throughout, except that on the inner faces and possibly above and below the punctuation is much closer; the longer hind tibial spur just longer than, and the shorter spur equal to, half the

length of the basal joint of the hind tarsus. *Abdomen*: 1st tergite (fig. 2, *f*) in apical half closely rugoso-punctate; 2nd tergite rugulose, with an apical sulcus separating it from the 3rd; 3rd and succeeding tergites lightly punctate (degree 1); ovipositor sheaths about equal to the shorter hind tibial spur.

Length, 3 mm.

TAHITI: Hitiaa, 3 ♀♀, 3♂♂, and one with abdomen missing, 9. vii. 1925, 10. vii. 1925, 7. viii. 1925 (*Miss L. E. Cheesman*).

Type in British Museum.

Host unknown.

Cocoons unknown.

34. **Apanteles anthelae**, sp. n.

♂. Black; legs (except coxae), tegulae, and basal ventrites, red testaceous; hind tibiae towards apex, and hind tarsi, somewhat darkened; palpi, hind tibial spurs, and narrow lateral margins of the 1st tergite, pale; 3rd and succeeding tergites varying from red-black to red-testaceous; stigma and wing veins red-brown.

♀. *Head* lightly punctate (degree 1). *Thorax*: mesonotum strongly and closely punctate (degree 5), almost rugoso- or reticulate-punctate; disc of scutellum with sparse, shallow, indefinite punctuation; propodeon with well marked, median longitudinal, and transverse basal, carinae, otherwise with rather indefinite sculpturing and with much shining area. *Wings*: the 1st abscissa of the radial, the transverse cubital, and the recurrent, all about equal, shorter than the breadth of the stigma, longer than the apical portion of the 1st abscissa of the cubital; stigma about as long as metacarp. *Legs*: hind coxae sparsely and very lightly punctate (degree 1); shorter hind tibial spur more than one-half, and the longer spur rather less than two-thirds, the length of the basal joint of the hind tarsus. *Abdomen*: 1st tergite (fig. 2, *g*) strongly and rather closely punctate (degree 5) in apical third; 2nd tergite indefinitely roughened throughout; 3rd and succeeding tergites apparently more or less completely smooth and shining; ovipositor sheaths apparently about equal in length to the longer hind tibial spur.

Length, 2·5–3·0 mm.

AUSTRALIA: Victoria, 8 ♀♀, undated.

Type in the British Museum. Four specimens bear a type label and a label in Cameron's writing "Apanteles dardalae, Cam. Type. Victoria," but this name does not appear to have been published.

Host. These four specimens bear a label recording that they were from an Anthelid larva, *Anthela ocellata*, Walk.

Cocoons white, and apparently solitary.

35. **Apanteles tiracholae**, Ashm.

Apanteles tiwacholae, Ashmead, Proc. U.S. Nat. Mus., xviii, no. 1092, 1896, p. 647.

♀♂. Black; scape and legs (except coxae) light red testaceous; the four anterior coxae red, the hind coxae black; hind femora apically tipped with black; hind tibiae towards apex, and hind tarsi, darkened; palpi pale; flagellum dull red; tegulae, stigma and wing veins red brown; narrow lateral margins of 1st and 2nd tergites pale; 3rd tergite variable, usually red testaceous, but occasionally nigrescent or black; basal ventrites red testaceous or yellow.

♀♂. *Head* punctate (degree 2). *Thorax*: mesonotum evenly and strongly punctate (degree 5), the punctures definitely separated; disc of scutellum with some scattered punctures (degree 3), mostly smooth and shining; propodeon rugose with median longitudinal carina from which emerge oblique carinae, and with strong basal transverse carinae. *Wings*: 1st abscissa of radial about equal to the breadth of the stigma, just longer than the recurrent; transverse cubital shorter than the recurrent, just longer than the apical portion of the 1st abscissa of the cubital, which latter about equals the pigmented portion of the 2nd abscissa of the cubital; stigma shorter than metacarp. *Legs*: hind coxae above basally with strong but very well separated punctures (degree 4); the longer hind tibial spur rather less than two-thirds, and the shorter spur one-half, the length of the basal joint of the hind tarsus. *Abdomen*: 1st tergite (fig. 2, *b*) in apical half strongly (degree 5) but sparsely punctate; 2nd tergite indefinitely sculptured, and bounded at apex and laterally by a well marked sulcus; 3rd tergite longer than the 2nd, this latter longer than the 4th; 3rd and succeeding tergites almost entirely smooth, polished and shining; ovipositor sheaths shorter than the shorter hind tibial spur.

Length: ♀, about 2·5; ♂, 2·25 mm.

Redescribed from a cotype presented by Dr. A. B. Gahan, through the Imperial Bureau of Entomology, to the British Museum, and from 5 ♀♀, 1 ♂, 10.i.1919 (*J. C. Hutson*) bred in Ceylon from larvae of the same host as the type and cotypes.

The type locality is Ceylon.

Host: the Noctuid, *Tirachola plagiata*, Walk.

Cocoons unknown.

Ashmead states definitely that the 2nd tergite is as long as the 4th, and that the 3rd is very short, whereas in reality the 2nd is longer than the 4th, and the 3rd is very long.

The sculpturing and punctuation of the 1st and 2nd tergites tend to become effaced, thus leaving the tergites almost entirely smooth.

36. Apanteles effrenus, sp. n. ♀♂

♀♂. Black; legs (except coxae), scape largely, flagellum largely beneath, basal ventrites, red testaceous; stigma and wing veins brown; palpi and tibial spurs pale; extreme apices of hind femora and of hind tibiae, hind tarsi, darkened somewhat.

♀♂. *Head* lightly punctate (degree 1). *Thorax*: mesonotum with coarse, fairly well separated punctures (degree 4–5); disc of scutellum with a few extremely weak and shallow punctures; propodeon with median longitudinal and transversely oblique carinae, and with very strong transverse basal ridges, otherwise more or less shining. *Wings*: 1st abscissa of the radial about equal to the breadth of the stigma, longer than the recurrent; transverse cubital shorter than the recurrent, about equal to the apical portion of the 1st abscissa of the cubital, which latter is longer than the pigmented portion of the 2nd abscissa of the cubital; stigma about equal to metacarp. *Legs*: hind coxae above with strong, well separated punctures (degree 4), otherwise apparently but sparsely and faintly punctate (degree 1); the longer hind tibial spur about two-thirds, and the shorter spur rather more than one-half, the length of the basal joint of the hind tarsus. *Abdomen*: 1st tergite (fig. 2,*c*) strongly punctate (degree 5) in apical half; 2nd tergite indefinitely sculptured and with well marked straight apical, and curved lateral, bounding sulci; 3rd tergite longer than 2nd, which latter is longer than the 4th; 3rd and succeeding tergites with some exceedingly faint punctuation (degree 1), largely smooth and polished; ovipositor sheaths shorter than the shorter hind tibial spur.

Length, 3 mm.

India: Dehra Dun, United Provinces, 5 ♀♀, 3 ♂♂, 16.iii.1925 (*G. D. Bhasin*).

Type deposited in the British Museum.

Hosts. Bred from a larva of an unknown species of Lepidoptera.

Cocoons unknown.

37. **Apanteles rufiventris,** Bingh.

Protapanteles rufiventris, Bingham, Trans. Ent. Soc. Lond., 1906, p. 127.

♀. Black; abdomen and legs (except as below), scape largely, shining red testaceous; hind coxae varying from a red testaceous like the abdomen, through dark red, to black; hind tibiae commonly dull red; hind tarsi brown; front and middle tibiae and tarsi approaching straminous; palpi and tibial spurs pale, with the mouth-parts otherwise red; 1st tergite like the hind coxae and varying as they vary; last abdominal tergite and sternite often nigrescent, but commonly not darkened; stigma brown with a pale spot at base, the flagellum of a darker brown; wing veins light brown, the costal vein and tegulae testaceous.

A species more variable in colour than usual, since the 1st tergite and the coxae can be either red testaceous or black.

♀. *Head* lightly punctate (degree 1); hind ocelli very noticeably further from one another than from the eyes. *Thorax*: mesonotum posteriorly with strong, well separated punctures (degree 4–5), anteriorly with the punctures still fairly well separated but smaller and more shallow (degree 3); disc of scutellum more or less faintly and sparsely punctate (degrees 1 and 2), polished; propodeon more or less strongly broadly rugoso-reticulate, with a definite median, longitudinal carina towards apex, and with the transverse basal carinae strongly marked. *Wings*: 1st abscissa of radial definitely longer than the transverse cubital, the angle of junction being definite though rounded; the transverse cubital longer than the recurrent, about equal to the apical portion of the 1st abscissa of the cubital; stigma in length about equal to metacarp, in breadth definitely greater than the length of the 1st abscissa of the radial. *Legs*: hind tibial spurs subequal, the shorter spur rather more than half the length of the basal joint of the hind tarsus; hind coxae basally above with a group of rather indefinite punctures (degree 3–4), on outer faces finely punctate (degree 1). *Abdomen*: 1st tergite (fig. 2, *d*) strongly punctate in apical half along each lateral third (degree 3 4), smooth along the middle and basally, indefinitely sculptured at apex; 2nd tergite more or less smooth medianly, indefinitely sculptured in each lateral third, with the lateral sulci definitely impressed but rather shallow; 3rd tergite longer than 2nd; ovipositor sheaths very short.

Length, 3 mm.

Redescribed from 14 ♀♀, all cotypes, in the collections of the British Museum.

The type locality is recorded as Townsville, North Queensland.

Host. Mr. Dodd records (Trans. Ent. Soc. Lond., 1906, p. 122) that this species parasitises the Lycaenid, *Ogyris zosine,* Hew.

Cocoons. Recorded by Mr. Dodd as white.

38. **Apanteles hypsipylae,** sp. n.

♀. Black; antennae largely, tegulae, costal veins, stigma, legs (except coxae), and ventrites, pale yellowish red testaceous; palpi and tibial spurs pale; tergites light red to dark red.

Probably immature specimens.

♀. Agrees well enough with my redescription of *A. rufiventris* except as follows :— *Head* : ocelli not or hardly further from one another than from the eyes ; propodeon with the median longitudinal and transverse basal carinae definitely present but not strongly marked. (*Wings* in every specimen too much damaged or undeveloped for the venation to be examined.) *Legs* : hind coxae basally above with strong separated punctures ; the hind tibial spurs attenuate, the longer spur possibly longer than two-thirds, and the shorter spur about three-fifths, the length of basal joint of hind tarsus. *Abdomen* : 1st tergite in shape much like that of *glomeratus* but somewhat wider at apex, thus approaching *rufiventris*, smooth in basal half, in apical half with strong well separated punctures (degree 4–5) ; 2nd tergite shaped like that of *glomeratus* only longer, punctate as strongly as, but definitely more sparsely than, the 1st tergite, with the lateral sulci strong.

Length, 2·5 mm.

INDIA : Balupur, Dehra Dun, United Provinces, 10 ♀♀, 6.ii.1925 (*N. C. Chatterjee*).

Type deposited in the British Museum.

Host. Recorded as parasitic on the Pyralid, *Hypsipyla robusta*, Moore.

Cocoons unknown.

COLLECTIONS RECEIVED.

The following collections were received by the Imperial Bureau of Entomology between 1st January and 31st March, 1928, and the thanks of the Managing Committee are tendered to the contributors for their kind assistance :—

Mr. W. Allen :—4 Orthoptera ; from Trinidad.

Capt. P. J. Barraud :—3 Culicid larvae, 4 Tabanidae, 100 Psychodidae, 260 other Diptera, 14 slides of Dipterous preparations, 64 Coleoptera, 17 Rhynchota, and 24 Orthoptera ; from the Punjab, India.

Dr. C. F. C. Beeson, Forest Entomologist :—178 Parasitic Hymenoptera and 15 Lepidoptera ; from Dehra Dun, India.

Dr. F. S. Bodenheimer : –202 Coleoptera and 5 larvae, 108 Hymenoptera, 5 Rhynchota, and 43 Orthoptera ; from Palestine.

Mr. G. E. Bodkin, Government Entomologist : —25 Diptera, 345 Coleoptera, 23 Hymenoptera, 31 Rhynchota, 21 Orthoptera, and 5 Ticks ; from Palestine.

Dr. G. Bondar :—4 Diptera and 29 Coleoptera ; from Brazil.

Mr. H. E. Box :—5 Diptera, 28 Coleoptera, 16 Hymenoptera, 56 Lepidoptera, and 37 Rhynchota ; from the Argentine Republic.

Prof. W. H. Brittain :—4 Diptera, 51 Coleoptera, 4 Hymenoptera, and 6 Rhynchota ; from Canada.

Bureau of Applied Entomology, Leningrad :—107 Orthoptera ; from North Caucasus.

Dr. P. A. Buxton, London School of Hygiene and Tropical Medicine :—32 Diptera, 58 Coleoptera, and 61 Orthoptera ; from various localities.

Chief Entomologist, Pretoria :—188 Coleoptera and 2 species of Coccidae ; from South Africa.

Chief Veterinary Officer, Kampala :—13 *Glossina* ; from Uganda.

Mr. E. C. Chubb, Durban Museum :—124 Rhynchota ; from South Africa.

Mr. L. D. Cleare, Junr., Government Entomologist :—19 Coleoptera and 3 early stages, 16 Chalcididae, 2 species of Coccidae, 6 species of Aphidae, and 4 Shells ; from British Guiana.

Prof. T. D. A. Cockerell :—10 Culicidae, 3 Tabanidae, 109 other Diptera, 96 Coleoptera, 12 Hymenoptera, 80 Lepidoptera, 4 species of Coccidae, 1 species of Aleurodidae, 105 other Rhynchota, 90 Orthoptera, 5 Odonata, 57 Trichoptera, 2 species of Fungus, 14 Shells, and 2 Squirrel skins ; from Siam.

Mr. G. H. Corbett, Government Entomologist :—55 Diptera, 10 Parasitic Hymenoptera, 46 other Hymenoptera, 72 Lepidoptera, 10 Rhynchota, and 7 Orthoptera ; from the Federated Malay States

Mr. G. S. Cotterell :—6 Diptera, 14 Coleoptera, 59 Parasitic Hymenoptera, 23 Lepidoptera, and 10 Rhynchota ; from the Gold Coast.

Mr. A. Cuthbertson :—3 *Stomoxys*, 11 other Diptera and 3 pupa-cases, and 3 Chalcididae ; from Southern Rhodesia.

Director of Veterinary Services, Pretoria :—10 Diptera, 280 Coleoptera and 22 larvae, 10 Dermaptera, 20 Collembola, and 100 Mites ; from South Africa.

Dr. H. S. Evans :—13 Culicidae, 25 Tabanidae, 28 other Diptera, 943 Coleoptera, 33 Hymenoptera, 16 Lepidoptera, 7 Isoptera, 34 Rhynchota, 11 Orthoptera, 7 Planipennia, 2 *Bittacus*, 10 Mites, and 7 Chelifers ; from the Belgian Congo.

Mr. T. Bainbrigge Fletcher, Imperial Entomologist :—210 Orthoptera ; from India.

Mr. C. French, jun. :—6 Curculionidae ; from Victoria, Australia.

Dr. P. C. C. Garnham :—488 Culicidae and 6 larvae ; from Kenya Colony.

Prof. G. E. Gates :—6 Diptera and 11 early stages ; from Burma.

Mr. J. Ghesquière :—104 Coleoptera and 7 Parasitic Hymenoptera ; from the Belgian Congo.

Government Entomologist, Coimbatore :—45 Coleoptera, 15 Lepidoptera, 11 Rhynchota, and 5 Dermaptera ; from South India.

The Governor, St. Helena :—9 Curculionidae and 8 larvae, and 400 Isoptera ; from St. Helena.

Mr. W. B. Gurney, Government Entomologist :—36 Rhynchota and 2 Hemerobiidae ; from New South Wales, Australia.

Mr. E. Hargreaves, Government Entomologist :—17 Diptera, 5 Coleoptera, 4 Hymenoptera, 25 Lepidoptera, 3 species of Coccidae, 40 other Rhynchota, 6 Orthoptera, and 2 Planipennia ; from Sierra Leone.

Mr. G. F. Hill, Entomologist :—32 Parasitic Hymenoptera, 8 Lepidoptera, 6 Psyllidae, and 20 Collembola ; from Victoria, Australia.

Mr. E. Hindle : — 37 Culicidae, 14 Tabanidae, 4 Hippoboscidae, 11 *Phlebotomus*, 364 other Diptera, and 763 Lepidoptera ; from China.

Mr. G. H. E. Hopkins, Assistant Medical Entomologist :—90 Siphonaptera, 4,600 Culicidae, 18 Tabanidae, 37 *Glossina*, 7 *Stomoxys*, 47 other Diptera, 38 Coleoptera, 88 Anoplura, 97 Ticks, 5 Mites, and 191 small Mammals ; from Kenya Colony.

Dr. W. Horn :—250 Orthoptera ; from Asia.

Mr. M. A. Husain, Government Entomologist :—6 Coleoptera and 4 species of Coccidae ; from the Punjab, India.

Dr. J. C. Hutson, Government Entomologist :—221 Diptera and 65 pupa-cases, 6 Coleoptera, 1,070 Parasitic Hymenoptera, and 173 Formicidae ; from Ceylon.

Prof. C. R. Kellogg :—3 Diptera, 559 Coleoptera, 8 Hymenoptera, 28 Rhynchota, 54 Orthoptera, 7 Planipennia, and 4 Shells ; from China.

Mr. S. S. Light :—250 Chalcididae ; from Ceylon.

Dr. C. A. Marelli :—29 Orthoptera ; from the Argentine Republic.

Mr. D. Miller, Government Entomologist :—5 Curculionidae ; from New Zealand.

Mr. N. C. E. Miller :—1 species of Coccidae ; from Tanganyika Territory.

Mr. L. D. Moritz :—70 Orthoptera ; from Transcaspia and Persia.

Dr. C. F. W. Muesebeck :—6 Parasitic Hymenoptera ; from Hungary.

Mr. H. K. Munro :—45 Diptera ; from South Africa.

Omsk Station for Plant Protection :—1,280 Orthoptera ; from Siberia.

Mr. W. H. Patterson, Government Entomologist :—4 tubes of Chalcididae and 4 tubes of Aleurodidae ; from the Gold Coast.

Mr. H. M. Pendlebury :—374 Parasitic Hymenoptera ; from the Malay Peninsula.

Mr. J. I. Roberts :—10 Diptera, 4 Coleoptera, 18 Parasitic Hymenoptera and 21 cocoons, and 6 Mites ; from Southern Rhodesia.

Royal Botanic Gardens, Kew :—3 Formicidae ; from Venezuela.

Mr. G. Salt :—61 Coleoptera ; from South America.

Mr. H. W. Simmonds, Government Entomologist :—20 Diptera, 44 Coleoptera, 6 Hymenoptera, 2 Rhynchota, and 3 Orthoptera ; from the Fiji Islands.

Mr. E. R. Speyer :—178 Coleoptera and 10 larvae, 19 Hymenoptera, 1 species of Aleurodidae, parasitised pupae and Chalcid parasites, 20 Collembola, 4 Mites, 5 Centipedes, 8 Millipedes, and 7 Oligochaeta ; from England and Guernsey.

Mr. F. H. Taylor :—27 Coleoptera, 20 larvae, and 8 pupae ; from Queensland, Australia.

Mr. A. Thèry :—38 Coleoptera ; from various localities.

Mr. H. P. Thomasset :—5 Siphonaptera, 18 other Diptera, 178 Coleoptera, 42 Hymenoptera, 344 Lepidoptera, 35 Rhynchota, 43 Orthoptera, 4 Planipennia, 7 Trichoptera, and 2 Spiders ; from Natal.

Dr. W. R. Thompson :—27 Parasitic Hymenoptera ; from France.

Mr. A. Tonnoir :—1 species of Coccidae ; from New Zealand.

Dr. D. L. Uyttenboogaart :—19 Coleoptera ; from the Canary Islands.

Wellcome Tropical Research Laboratories, Khartoum :—33 Diptera, 319 Coleoptera, 61 Parasitic Hymenoptera, 45 other Hymenoptera, 20 Lepidoptera, 45 Rhynchota, and 14 scorpions and 6 young ; from the Sudan.

A REVISION OF THE INDO-AUSTRALIAN SPECIES OF THE GENUS *APANTELES* (HYM. BRACON.).—PART II.

By D. S. Wilkinson,

Senior Assistant, Imperial Bureau of Entomology.

39. Apanteles taeniaticornis, sp. n.

♀. Black; the four front legs (except their coxae), the basal third of the hind tibiae, red testaceous; hind femora red to red-black; basal ventrites and the lateral membranous margins of the 1st tergite pale reddish; palpi and hind tibial spurs white; the 9th to the 12th flagellar joints inclusive entirely cream-white; the apical half of the 8th, and the basal half of the 13th joint, rather pale; ovipositor red; stigma and wing veins dark brown; wings infumated.

♀. *Head* finely punctate (degree 1). *Thorax*: mesonotum regularly and separately punctate (degree 3); disc of scutellum with some fine punctures (degree 1); propodeon with the carinae strong; the areola complete, basally almost as broad as at the point of emission of the costulae, with strong indications of a transverse division roughly midway between base and costulae; costulae sloping downwards; the spiracular areae complete; apart from this more or less complete areation, the propodeon is virtually devoid of sculpture. *Wings*: 1st abscissa of radial rather strongly curved, in length about equal to the recurrent, rather shorter than the breadth of the stigma, its point of junction with the transverse cubital apparent; the transverse cubital straight, about equal to the pigmented portion of the 2nd abscissa of the cubital, rather longer than the upper portion of the basal vein, definitely shorter than the apical portion of the 1st abscissa of the cubital, this latter being considerably shorter than the recurrent; stigma shorter than metacarp. *Legs*: hind coxae finely and evenly punctate (degree 1) except on outer face which is more or less bare; the longer hind tibial spur about half, and the shorter spur about one-third, the length of the basal joint of the hind tarsus. *Abdomen*: 1st tergite elongate, about 2·5 times as long as broad at base, with the sides straight and converging to apex, which is half as broad as base, basally strongly excavate, medianly strongly tumescent and arched, the dull tumescence indefinitely sculptured and setiferous,elsewhere more or less smooth, shining, and impunctate; 2nd tergite apparently more or less triangular and very short, about four times as broad as long down the middle, this length about equal to the apical breadth of the 1st tergite, smooth and shining, as are all the succeeding tergites; the 2nd suture very fine and hardly determinable; ovipositor sheaths equal in length to the hind femur.

Length, 3 mm.

Java: Tjibodas, 5,000–7,000 ft., 2 ♀♀, viii.1913 (*Dr. Koningsberger*).

Type in the British Museum.

Host unknown.

Cocoons unknown.

This species is extremely interesting on account of the white band on the antennae. It should be remarked that in the only other species known to me that exhibits this unusual feature, namely in *A. annulicornis*, Ashm., the flagellum of the males is quite normal, only that of the females being banded. *A. annulicornis* was described from the West Indies.

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40. Apanteles recusans, Walk.

Microgaster recusans, Walker, Ann. Mag. Nat. Hist., (3) v, 1860, p. 308.

♀. Black ; in the front legs the coxae, trochanters, and basal half of the femora, and the apical half of the middle tibiae, reddish ; apical half of front femora, front tibiae, basal half of middle tibiae, front and middle tarsi, basal third of hind tibiae, basal ventrites, lateral membranous margins of the 1st tergite, and the parastigma, pale reddish testaceous ; palpi and hind tibial spurs white ; tegulae red ; stigma and wing veins dark brown ; wings infumate.

♀. *Head* rugose. *Thorax*: mesonotum and disc of scutellum rugose ; mesopleurae in front, and below largely, rugose, with numerous fine striae extending from the rugose areas to the hinder smooth shining area ; propodeon rugose with a strong median longitudinal carina. *Wings*: the 1st abscissa of the radial hardly as long as the breadth of the stigma, slightly curved, very stout ; the transverse cubital very stout ; stigma shorter than metacarp. *Legs* : hind coxae largely rugose ; the longer hind tibial spur half, and the shorter spur two-fifths, the length of the basal joint of the hind tarsus. *Abdomen* : 1st tergite rugose, about 1·25 times as long as broad at base, with the sides parallel in the basal half, thence the sides converging to the apex, which is truncate and rather less than half as broad as the length of the tergite ; 2nd tergite rugose, very short, about half as long as the apical breadth of the 1st tergite, about six times as broad as long ; 3rd tergite punctato-reticulate in the apical two-thirds ; ovipositor sheaths equal in length to the hind tibia.

Length, 2·5 mm.

Re-described from Walker's type, which is in the British Museum.

The type locality is Ceylon.

Host unrecorded.

Cocoons unknown.

41. Apanteles detrectans, sp. n. ♀

♀. Black ; front legs (except basal half of the femora), middle legs from the extreme apex of the femora distally, and basal half of hind tibiae, red testaceous ; tegulae, costal vein, margins of stigma, reddish testaceous ; palpi and tibial spurs pale ; stigma discally hyaline ; metacarp brown ; other veins virtually colourless ; wings hyaline.

♀. *Head* : face finely punctate (degree 1–2) ; vertex behind the ocelli, and orbits behind, closely and finely rugose. *Thorax* : mesonotum and disc of scutellum finely, regularly, and separately punctate (degree 2), the former rather more strongly laterally, and the latter somewhat more sparsely than the former ; propodeon sparsely and very finely punctate (degree 1–2), otherwise unsculptured save for a well marked, strong, median, longitudinal carina, which in the apical half widens or bifurcates so as to form a raised, smooth, flat, triangular area; down each side of this carina and raised triangular area the propodeon is more or less crenulate or with very short carinae running transversely. *Wings* : 1st abscissa of the radial rather shorter than the breadth of the stigma, a little longer than the recurrent, which is definitely longer than the apical portion of the 1st abscissa of the cubital and also than the transverse cubital, these two latter being about equal ; the upper portion of the basal vein somewhat shorter than the transverse cubital but somewhat longer than the pigmented portion of the 2nd abscissa of the cubital ; stigma longer than metacarp. *Legs*: hind coxae above basally somewhat rugose, but extremely finely and shallowly ; on outer face sparsely and finely punctate (degree 1) ; the longer hind tibial spur just slightly longer than half, and the shorter spur just shorter than two-fifths, the length of the basal joint of the hind tarsus. *Abdomen* : 1st tergite about 2·5 times as broad at base as at apex, and about three times as long down middle as the apical

width ; at the middle nearly as broad as at base, thence with the sides more quickly converging to the truncated apex ; this tergite is arched, slightly excavate basally, where it is entirely smooth, and in the apical half very sparsely and finely punctate ; the extreme apex somewhat tumescent, highly polished and shining ; 2nd tergite short, in length about half the breadth of the 1st tergite at apex, in breadth about equal to or somewhat less than the length of the 1st tergite; 2nd and succeeding tergites virtually impunctate save for some extremely sparse and fine punctures ; ovipositor sheaths about equal to or rather longer than the hind tibia, definitely shorter than the hind tarsus.

Length, 3 mm.

INDIA : Pusa, 4 ♀♀, 13–25.vi.1919 (*T. B. Fletcher*).

Type deposited in the British Museum.

Host. Recorded as parasitic on a Phycitid larva.

Cocoons white, solitary.

42. Apanteles cajani, sp. n.

♀. Agrees with my description of the colour of *A. detrectans* except that the hind legs, where not testaceous, are more reddish and not quite so deeply black, and that the metacarp is paler.

♂. Black ; the front legs distally from apex of femora, middle tarsi, middle tibiae basally, hind tibiae basally, red testaceous ; palpi and tegulae brownish ; tibial spurs pale ; wings as in ♀.

♀♂. *Head* : face punctate (degree 2) ; antennae in ♀♀ definitely shorter than, and in ♂♂ definitely longer than, combined lengths of head, thorax, and abdomen. *Thorax* : mesonotum with strong, close but separated, punctures (degrees 4 and 5), medianly posteriorly striate ; disc of scutellum largely polished and shining, with a few very faint punctures (degree 1) along the margins commonly more strongly punctate (degree 3 and 4), but these latter punctures often absent, much flattened and evenly rounded with the lateral faces, from which it is only separable on account of the semicircular sulci ; the smooth shining areas enclosed by the semicircular sulci on the lateral faces of the scutellum are more or less finely aciculate above ; propodeon as in *A. detrectans*, except that the punctation is rather stronger (degree 3). *Wings* : venation variable ; 1st abscissa of the radial usually a little longer than the breadth of the stigma, which is greater than the length of the recurrent ; the recurrent, transverse cubital, and apical portion of the 1st abscissa of the cubital usually all about equal (although each length is variable without reference to the others), longer than the upper portion of the basal vein, which latter is definitely longer than the pigmented portion of the 2nd abscissa of the cubital ; stigma shorter than metacarp. *Legs* : hind coxae sparsely and finely punctate on outer faces (degree 2), basally above more closely and almost aciculately or finely rugosely punctate ; the longer hind tibial spur about half, and the shorter spur one-third, the length of the basal joint of the hind tarsus. *Abdomen* : 1st tergite in ♀ about twice as broad at base as at apex, and about 1·5 times as long down middle as the basal width, at middle nearly as broad as at base, thence with the sides somewhat more quickly converging to the truncated apex ; this tergite is strongly arched and is slightly excavate basally, where it is entirely smooth, polished, and shining, but in the apical half it is furnished with strong (degree 3–4), often somewhat aciculate, and always extremely well separated, punctures, more sparsely punctate as the apex is approached, and more or less entirely impunctate in the apical quarter ; the punctate area divided into two by a median, longitudinal, more or less well defined, impunctate, smooth, level stripe, which in breadth does not exceed one-sixth the breadth of the tergite ; ♂, as for female, except that the tergite is definitely narrower at apex ; 2nd tergite of ♀, with the basal breadth definitely greater than length down middle, this latter about a

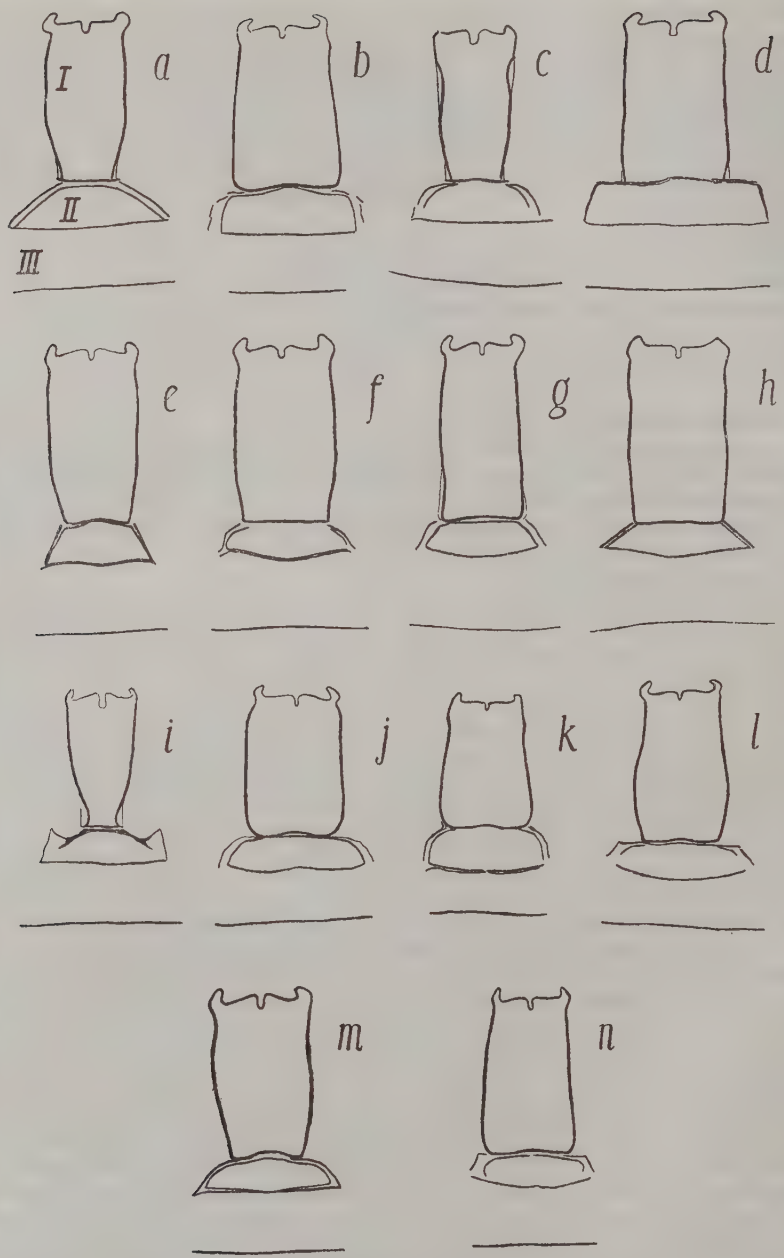

Fig. 3. First, second, and third tergites of: (*a*) *A. javensis*, ♀; (*b*) *A. caniae*, ♀; (*c*) *A. hyblaeae*, ♂; (*d*) *A. hyblaeae*, ♀; (*e*) *A. araeceri*, ♂; (*f*) *A. araeceri*, ♀; (*g*) *A. prodeniae*, ♀; (*h*) *A. machaeralis*, ♀; (*i*) *A. calycinae*, ♀; (*j*) *A. hyposidrae*, ♀; (*k*) *A. expulsus*, ♀; (*l*) *A. agilis*, ♀; (*m*) *A. tachardiae*, ♀; (*n*) *A. parasae*, ♀. (×50.)

third of the apical breadth, which is about equal to the basal breadth of 1st tergite, in apical half with very well-separated, strong, distinct punctures (degree 3–4), otherwise smooth, with the lateral sulci rounded and well-marked ; ♂, basal breadth just greater than length down middle, this latter one-third of apical breadth, which is rather greater than the basal breath of the 1st tergite, with the lateral sulci straight and well-marked, weakly punctate in apical half (degree 2) ; 3rd tergite very long, as long as basal breadth of 1st tergite, and, as in the succeeding tergites, finely (degree 1) and sparsely punctate ; ovipositor sheaths noticeably longer than the hind tarsi.

Length, ♀ 3·5 mm., ♂ 3·0 mm., and one ♀ that is barely 3·0 mm.

INDIA: Pusa, Bihar, 6 ♀♀, 4 ♂♂, 28–30.vi.1914, 1–21.vii.1914.

Type deposited in the British Museum.

Cocoons unknown.

43. Apanteles javensis, Rohw.

Apanteles javensis, Rohwer, Proc. U.S. Nat. Mus., liv, no. 2249, 1918 (1919), p. 567.

♀. Black ; antennae, tegulae, hind legs largely, middle legs to near apex of femora, front legs to base of femora, basal ventrites, lateral membranous margins of the 1st tergite, deep red ; legs otherwise red testaceous ; the hind tarsi and the basal half of the hind tibiae lighter than the apical half of the hind tibiae ; costal vein, stigma, and metacarp opaque yellowish, the stigma often with margins brownish ; other veins more or less colourless ; palpi and tibial spurs almost white.

♀. *Head* with close, shallow, indefinite punctation. *Thorax* : mesonotum with definite (degree 3 about) but more or less confluent and shallow punctation, with strong tendencies to become aciculate or striate medianly posteriorly ; disc of scutellum virtually entirely smooth, shining, and impunctate, but there are a few exceedingly fine punctures (degree 1) ; propodeon with the areola well marked in the apical half, otherwise indefinitely sculptured and dullish, the areola more shining. *Wings* : the 1st abscissa of the radial a little longer than the breadth of the stigma, this latter apparently a little longer than the recurrent, this again somewhat longer than the transverse cubital ; the apical portion of the 1st abscissa of the cubital apparently about equal to the upper portion of the basal vein, these shorter than the transverse cubital but longer than the pigmented portion of the 2nd abscissa of the cubital ; veins very faint and difficult to deliminate ; stigma about equal to metacarp. *Legs* : hind coxae on outer faces sparsely and extremely finely punctate (degree 1), basally above with a small area more definitely punctate ; the longer hind tibial spur just about half, and the shorter spur definitely less than half but more than a third the length of the basal joint of the hind tarsus. *Abdomen* : 1st tergite (fig. 3, *a*) punctate along the marginal third in the apical half, except at apex ; 2nd tergite completely smooth and shining save for a very few extremely fine punctures ; ovipositor sheaths in length about equal to the basal joint of the hind tarsus.

Length, 2·25 mm.

Redescribed from two female cotypes presented by Dr. A. B. Gahan, through the Imperial Bureau of Entomology, to the British Museum, and from 6 ♀♀, x.1911 (*Dr. Karny*) bred from the same host and in the same locality as the type series.

The type locality is Buitenzorg, Java.

Host. The Hesperiid, *Parnara conjuncta*, H.-S.

Cocoons unknown.

44. Apanteles calycinae, sp. n.

♀♂. Black ; legs, except as below, red testaceous ; all coxae black ; trochanters often darkened ; middle femora narrowly above, middle tibiae towards apex some-

what, hind femora more or less broadly above, hind tibiae in apical half, each hind tarsal joint somewhat at apex, nigrescent; the base of all the tarsal joints, all tibiae towards base, palpi and tibial spurs, pale to white; the basal ventrites and the lateral membranous margins of the 1st tergite more or less dark red; stigma and wing veins brown.

♀♂. *Head* finely punctate (degree 1). *Thorax*: mesonotum more or less separately, and finely, punctate (degree 1–2); disc of scutellum much flattened, smooth, highly polished and shining, with but only a few extremely fine punctures (degree 1); propodeon with the areola only noticeable in the apical half, where it is somewhat weakly marked by two or three striae on each side; basally the propodeon is smooth save for some weak scattered punctures (degree 1), apically it has some indefinite, weak sculpture. *Wings*: the breadth of the stigma, and the lengths of the 1st abscissa of the radial and the transverse cubital, all about equal, the recurrent just slightly shorter; the apical portion of the 1st abscissa of the cubital definitely shorter than the recurrent, a little longer than the upper portion of the basal vein, about equal to the pigmented portion of the 2nd abscissa of the cubital; stigma shorter than metacarp; the venational characters are rather variable, except for the radial and transverse cubital veins. *Legs*: hind coxae shining and finely punctate (degree 1), possibly somewhat more strongly punctate above basally (degree 2); the longer hind tibial spur about half, and the shorter spur about a third, the length of the basal joint of the hind tarsus. *Abdomen*: 1st tergite (fig. 3, *i*) finely and rather indefinitely punctate in the apical half, with some definitely stronger sculpturing towards apex medianly; all succeeding tergites smooth and shining, and each with apparently a single transverse row of very fine punctures; ovipositor sheaths as long as the hind tarsus.

Length, about 2·5 mm.

INDIA: Barkote, Dehra Dun, 1 ♀ (type), 2 ♂♂, 11–23.iii.1926 (*N. C. Chatterjee*); Jhajra, Dehra Dun, 5 ♀♀, 3 ♂♂, 30.ix.1925, 25.x.1925, 1–29.xi.1925, 9.xii.1925 (*B. M. Bhatia*).

Type deposited in the British Museum.

Host. The first series is recorded as having been bred from the Malvaceous plant, *Kydia calycina*, Roxb., and the second series from the Dipteraceous tree, *Shorea robusta*, Gaertn. There is no true host record.

Cocoons unknown.

45. Apanteles hyblaeae, sp. n.

♀♂. Black; the four anterior legs (except the coxae), hind trochanters and hind femora, about basal half of hind tibiae, each hind tarsal joint at base somewhat, bright red testaceous; apical half of the hind tibiae, and the hind tarsi largely, strongly nigrescent; scape and ventrites largely red testaceous; flagellum dull reddish black; tegulae dark red to black; mouth-parts largely reddish; hind tibial spurs white; stigma and wing veins brown.

The 3rd tergite appears to be somewhat reddish.

♀♂. *Head* with more or less definite but extremely shallow punctation (degree 2). *Thorax*: mesonotum with definite, more or less separated, shallow punctation; the disc of the scutellum absolutely impunctate, highly polished and shining, evenly rounded with the lateral faces; propodeon apically more or less weakly rugosely carinate, basally more or less indefinitely punctate (degree 2–3), the areola medianly indicated by being smoother and slightly excavate, apically indicated by carinae. *Wings*: 1st abscissa of radial equal to or possibly even just longer than the breadth of the stigma, fairly straight, successively thicker below, fairly well marked from the transverse cubital, which latter is thicker again and about equal in length to but often

noticeably thicker than and also commonly longer than the apical portion of the 1st abscissa of the cubital; the upper portion of the basal vein shorter than the apical portion of the 1st abscissa of the cubital but longer than the pigmented portion of the 2nd abscissa of the cubital; recurrent longer than the transverse cubital; stigma shorter than metacarp; venational characters largely inconstant. *Legs*: hind coxae on outer face above finely and sparsely punctate (degree 1), on inner face rather more strongly and closely punctate apparently (degree 2), above basally with a few fairly strong, separated punctures (degree 3); the longer hind tibial spur half, and the shorter spur rather more than a third the length of the basal joint of the hind tarsus. *Abdomen*: 1st tergite in the ♀ (fig. 3, *d*) more or less indefinitely punctate-striate along each lateral third in the apical half, in the ♂ (fig. 3, *c*) almost entirely smooth save towards the sides at about the middle, where there are some very indefinite but distinct sculptures; 2nd and succeeding tergites virtually smooth save for some fine punctures (degree 1); ovipositor sheaths about as long as the hind tarsus.

Length, 2·5–3·0 mm.

SAMOAN IS.: Apia, Upolu I., 7 ♀♀ (one the type), 2 ♂♂, 26.vi.1924 (*P. A. Buxton* and *G. H. Hopkins*). JAVA: Djohore, 81 ♀♀, 8 ♂♂, vi.1925 (*B. van der Goot*).

Type deposited in the British Museum.

Host. The Samoan series, I am informed by Dr. Buxton, was bred from the Noctuid, *Hyblaea sanguinea*, Gaede; the series from Java is labelled as parasitic on *Hyblaea puera*, Cram.

Cocoons unknown.

There are certain differences between these two series, but they are not, either in my opinion or in that of Dr. A. B. Gahan, of sufficient value to justify the separation of these insects into two species. The characters to which I refer are as follows:— The transverse cubital is decidedly more swollen in the Samoan series; the 1st tergite in the Samoan series is slightly distended at apex, while in the specimens from Java its sides are more parallel as a rule; the Samoan insects are usually the larger. These characters are not constant, however, and cannot be referred with any certainty either to one side or to the other; I have thought it advisable, therefore, not even to separate this series into subspecies. The thickening of the transverse cubital and of the 1st abscissa of the radial below would seem to be the most satisfactory character on which to divide this series; the venation in this species, however, would seem to be curiously unstable. I have one or two damaged specimens bred from *H. sanguinea* in Samoa where the transverse cubital equals or is greater than the 1st abscissa of the radial. If these two series are to be separated, further biological data must be forthcoming; I have not even seen their cocoons.

46. **Apanteles singaporensis,** Szép.

Apanteles singaporensis, Szépligeti, Ann. Mus. Nat. Hung., iii, 1905, p. 49.

♀. Black; forelegs distally from about middle of femora, middle tibiae somewhat at extreme base, middle tarsi, red testaceous; palpi and tibial spurs pale; wings clear hyaline, the veins (except as below) virtually colourless; costal vein red testaceous, darkening somewhat towards apex; stigma hyaline save for its margins which are reddish brown; metacarp opaque red-brown; transverse cubital and pigmented portion of the 2nd cubital slightly reddish testaceous.

♀. *Head* for the most part closely and finely rugose and strongly setiferous; face not rugose, closely punctate (degree 2). *Thorax*: mesonotum and mesopleurae mostly closely rugose, dull, and strongly setiferous; disc of scutellum with close shallow punctures, almost closely rugose, and strongly setiferous particularly along the lateral thirds, but also medianly to a less degree; propodeon apically with the areola U-shaped and well marked, basally with its limitations strongly indicated;

costulae definitely absent ; propodeon otherwise indefinitely sculptured, with some punctures (degree 2–3) basally which tend towards rugosity. *Wings* : 1st abscissa of the radial in length about equal to the breadth of the stigma, a little longer than the recurrent, nearly twice the length of the transverse cubital, which latter is about equal to the upper portion of the basal vein but longer than the pigmented portion of the 2nd abscissa of the cubital ; the apical portion of the 1st abscissa of the cubital is a little shorter than the recurrent but longer than the transvesre cubital ; stigma about equal to or just shorter than metacarp. *Legs* : hind coxae finely but shallowly punctate (degree 1–2) apparently evenly more or less throughout ; the longer hind tibial spur half, and the shorter spur less than two-fifths but more than one-third, the length of the basal joint of the hind tarsus. *Abdomen* : 1st tergite in basal half smooth, in apical half rugose, about 1·5 times as long as broad, with the sides in the apical quarters just slightly converging to the truncated apex, which latter, however, is about as broad as the base of the tergite ; the basal half of the tergite is longitudinally rugulose along the lateral margins, while discally the tergite is evidently more or less tumescent ; 2nd tergite about twice as broad as the apex of the 1st tergite, with its breadth rather less than four times its median length, smooth save for some indefinite rugosity all across the apical half ; 3rd tergite about 1·7 times as long as the 2nd, smooth save for some weak scattered punctation (degree 1) ; ovipositor sheaths a little longer than the hind tibia and a little shorter than the hind tarsus.

Length about or rather more than 2·5 mm.

Redescribed from two females, both labelled as type, which were very kindly lent me by Dr. Biró.

Type in the Hungarian National Museum.

The type locality is Singapore.

Host unknown.

Cocoons unknown.

47. Apanteles leptothecus, Cam.

Pseudapanteles leptothecus, Cameron, J. Bombay Nat. Hist. Soc., xvii , 1907, p. 585.

♀. Black ; about apical half of front femora, front tibiae, front and middle tarsi, both hind tibiae and basal joint of hind tarsi at extreme base, middle tibiae basally, red testaceous ; hind tibial spurs white ; wing veins colourless except the costal vein and the metacarp which are extremely pale reddish ; stigma hyaline except round the margins.

♀. *Thorax* : mesonotum finely punctate (degree 2); disc of scutellum possibly somewhat punctate (degree 1) towards the margins ; propodeon with faint indications of areolar carinae at extreme apex, medianly roundly excavate, otherwise more or less completely smooth, shining, and unsculptured save for some exceedingly fine punctures (degree 1). *Wings* : stigma equal to or slightly longer than the metacarp. *Legs* : hind coxae evenly and finely punctate (degree 2) more or less throughout, definitely more sparsely punctate on the outer than on the inner faces ; the longer hind tibial spur rather less than half, and the shorter spur rather less than a third, the length of the basal joint of the hind tarsus. *Abdomen* : (missing) ; Cameron in his original description says " 1st abdominal segment almost square, depressed in the middle at the base, the other segments are wider than long, transverse, smooth and shining . . . ovipositor 2 mm. . . . length 4·5 mm."

Re-described from Cameron's type, which is in the British Museum.

The type locality is Deesa, Bombay Presidency, India.

Host unknown.

Cocoons unknown.

48. Apanteles phycodis, Vier.

Apanteles (*Apanteles*) *phycodis*, Viereck, Proc. U.S. Nat. Mus., xliv, no. 1968, 1913, p. 557.

♀. Black; forelegs distally from base of the femora, middle legs distally from the apical third of the femora, the hind tarsi, and the basal two-thirds of the hind tibiae, red testaceous; remainder of legs, except coxae, dark red to red black; palpi yellowish; tibial spurs whitish; tegulae apparently dark red to black; costal vein red testaceous; stigma white with its margins brownish; metacarp brownish.

♀. *Head* much as in *A. singaporensis* except that the face is more definitely punctate (degree 2–3) and that the rugosity is definitely coarser and completely surrounds the ocelli. *Thorax*: mesonotum strongly and closely punctate (degree 5), posteriorly the punctures virtually contiguous and so close that the integument is striato-punctate; disc of scutellum extremely like that of *A. singaporensis*, except that it is more strongly rugosely striate laterally, that it is more shining and not so punctate discally, and that it is not so strongly setiferous; the smooth shining area on each lateral face of the scutellum unusually small, not, or hardly, as long as the breadth of the disc of the scutellum at apex; propodeon in basal quarter with one (or ? two) strong median longitudinal carina which reaches to the base of the strongly marked areola; the base of the areola transversely straight, the basal angles therefore being acute; the lateral bounding carinae of the areola are weaker than the basal carina, but they also are more or less straight, the apical angle of the areola therefore being apparently acute; propodeon otherwise shining and with more or less indefinite sculpture in the form of wavy, mostly transverse, carinae; costulae or basal transverse ridges definitely absent. *Wings*: 1st abscissa of the radial longer than the breadth of the stigma, this latter about equal to or just slightly greater than the length of the recurrent; the apical portion of the 1st abscissa of the cubital definitely much shorter than the recurrent, just longer than the transverse cubital which is longer than the upper portion of the basal vein, this latter being longer than the pigmented portion of the 2nd abscissa of the cubital; stigma shorter than metacarp. *Legs*: hind coxae apparently more or less generally punctate; the longer hind tibial spur two-fifths, and the shorter spur two-sevenths, length basal joint of the hind tarsus. *Abdomen*: 1st tergite in shape more or less a regular right angled parallelogram, nearly twice as long as broad, more or less indefinitely longitudinally striate, slightly tumescent medially; 2nd tergite basally as broad as the apex of the 1st tergite, apically as broad as its basal breadth plus its medial length, the medial length being two-fifths the basal breadth; the 2nd tergite is more or less quite smooth, or at the most extremely indefinitely sculptured; ovipositor sheaths longer than the hind tarsus, about as long as the combined lengths of the hind tibia and the basal joint of the hind tarsus.

Length, about 2·8 mm.

Redescribed from one female cotype presented by Dr. A. B. Gahan, through the Imperial Bureau of Entomology, to the British Museum.

The type locality is Bangalore, India.

Host. The Microlepidopteron, *Phycodes radiata*, Ochs., of the family GLYPHIPTERYGIDAE.

Cocoons unknown.

49. Apanteles leptoura, Cam.

Apanteles leptoura, Cameron, Spol. Zeylan., vi, pt. 21, 1909, p. 43.

♀. Black; front legs from the femora outwards, middle legs distally from about the middle of the femora, the basal two-thirds of the hind tibiae, the hind tarsi (except

the apical half of the basal joint), the costal veins and metacarp, stigma (except for a small hyaline patch discally), red testaceous ; palpi and tibial spurs pale ; wings hyaline; veins colourless.

♀. *Head* : face closely punctate (degree 3–4), in places striato-punctate or almost rugosely punctate ; orbits, cheeks, and vertex, rugose. *Thorax* : mesonotum with strong, separated punctation (degrees 4 and 5), except that along the line of the notauli the punctures are more uniform in size (degree 5), and are virtually contiguous, posteriorly tending to form striae ; disc of scutellum entirely smooth and shining save for some sparse, weak punctation (degree 3) along lateral margins ; the smooth shining area on each lateral face of the scutellum large and definitely longer than the breadth of the disc of the scutellum at apex ; propodeon with the areola U-shaped, well marked, and complete, being closed basally by a well-marked transverse carina ; the lateral carinae of the areola continued to the base of the propodeon ; the areola somewhat shining discally, exhibiting only a few indefinite transverse carinae ; otherwise the propodeon basally more or less rugoso-punctate, towards apex with some fairly definite transverse carinae, and apically more or less completely smooth. *Wings* : the length of the recurrent equal to the breadth of the stigma, definitely shorter than the 1st abscissa of the radial, definitely longer than the transverse cubital, which latter is just a little longer than the apical portion of the 1st abscissa of the cubital ; the upper portion of the basal vein definitely shorter than the transverse cubital, nearly twice as long as the pigmented portion of the 2nd abscissa of the cubital ; stigma shorter than metacarp. *Legs* : hind coxae but dully shining, above basally somewhat punctate, otherwise apparently entirely closely and minutely striate ; the longer hind tibial spur half, and the shorter spur a third, the length of the basal joint of the hind tarsus. *Abdomen* : 1st tergite in shape more or less a regular right-angled parallelogram, as broad at base as at apex, at about the base of the apical third just a little broader than at the base of the tergite (26 : 22), just about 1·5 times as long as broad at base, in basal third smooth and shining, otherwise rugose, with a narrow, rather indefinite, median, longitudinal excavation in the apical two-thirds ; 2nd tergite nearly twice as broad at apex as at base, and with the apical width about five times the median length, entirely smooth and shining, as are the remaining tergites, save for the usual transverse row of extremely weak punctures ; 3rd tergite just more than twice as long as the 2nd ; ovipositor sheaths a little longer than the hind tibia, shorter than the hind tarsus.

Length, 3·6 mm.

Redescribed from the type, which is in the British Museum.

The type locality is Madulsima, Ceylon.

Host. A *Tortrix* larva in stems of dadap.

Cocoons white, and presumably solitary.

50. Apanteles araeceri, sp. n.

♀. Black ; at least apical half of front femora, front tibiae, less than apical half of middle femora, middle tibiae largely, basal half of hind tibiae, basal half of the basal joint of the hind tarsi, red testaceous ; the four front tarsi more or less nigrescent, as are the apices of the middle tibiae ; palpi and tibial spurs pale to white ; costal veins and stigma bordered with brown and discally varying from hyaline to completely opaque white ; metacarp brown.

♂. Less than apical half of front femora, front tibiae largely, middle femora at extreme apex, basal third of middle tibiae, basal third of hind tibiae, basal joint of the hind tarsus at extreme base, red testaceous ; front tibiae at apex above, front and middle tarsi, somewhat nigrescent ; otherwise agrees with the colour description of the female.

♀♂. *Head* largely rugulose except that the face varies from rather indefinitely punctate (degree 3) to indefinitely subruguloso-punctate. *Thorax*: mesonotum separately and strongly punctate (degree 4–5), virtually rugoso-punctate along the lines of the notauli and medianly behind; mesopleurae anteriorly rugulose; disc of scutellum impunctate, shining; propodeon in basal third with a short, strong, median, longitudinal carina; the lateral carinae of the strong, well marked areola commonly extend upwards towards the base of the propodeon beyond the apex of the median longitudinal carina, from which apex there extend one or two pairs of transverse or oblique carinae which, though commonly weak and more or less indefinite, are often strong and often reach to the lateral carinae of the areola, giving to the areola a closed appearance; propodeon in apical half shining, with numerous transverse carinae, basally rugose and dull. *Wings*: the 1st abscissa of the radial definitely longer than the breadth of the stigma, which is about equal to the length of the recurrent, this latter being a little longer than the transverse cubital; the apical portion of the 1st abscissa of the cubital a little shorter than the transverse cubital, definitely shorter than the upper portion of the basal vein, about twice as long as the pigmented portion of the 2nd abscissa of the cubital; stigma shorter than metacarp. *Legs*: hind coxae above rugulose or ruguloso-punctate, below this on outer face extremely finely and closely striate, medianly on outer face extremely finely punctate (degree 1); the longer hind tibial spur rather longer than half, and the shorter spur about a third, the length of the basal joint of the hind tarsus. *Abdomen*: 1st tergite (fig. 3, *e, f*) rugose in apical half, with a median, longitudinal, shallow, flat, narrow excavation, which is rather indefinite in the females and very indefinite in the males; 2nd tergite more or less smooth save for a few definite punctures (degree 3), these punctures virtually absent in the males, about half as long as the 3rd tergite in the females, in the males rather longer; ovipositor sheaths elongate, considerably longer than the hind tarsus, about as long as the combined lengths of the hind tibia and the basal joint of the hind tarsus.

Length averaging 3 mm.

JAVA: Deli, 29 ♀♀, 24 ♂♂, xii.1925 (*B. van der Goot*).

Type deposited in the British Museum.

Host. Bred from the Anthribid, *Araecerus fasciculatus*, DeG.

Cocoons unknown.

51. Apanteles tachardiae, Cam.

Apanteles tachardiae, Cameron, Indian Forest Rec., iv, pt. 2, 1913, p. 19.

♀. Black; front legs distally from about the middle of the femora, middle femora at extreme apex, middle tibiae and tarsi, basal half of hind tibiae, hind tarsi, costal veins, extreme margins of stigma, and metacarp, red testaceous; the distal portion of the middle tibiae and of the hind tarsal joints often darkened in varying degrees; the front femora occasionally almost completely red testaceous; palpi and tibial spurs pale; wing veins mostly colourless; stigma (save for extreme margins) hyaline.

♀. *Head*: vertex and occiput largely lightly rugose; frons and frontal orbits very finely striate; face extremely finely and rather closely punctate (degree 1). *Thorax*: mesonotum with close, shallow punctation (degree 3); scutellum impunctate, polished, shining, save for some indefinite punctures (degree 2) down extreme margins; propodeon with areola in apical half well marked by distinct carinae and by being definitely somewhat sunken and more or less devoid of rugosity; basally the areola reaches to the base of the propodeon, is normally devoid of bounding carinae, but is distinctly marked through being sunken and almost devoid of rugosity; propodeon lightly rugose basally, often smooth and shining apically. *Wings*: length of 1st abscissa of the radial equal to the breadth of the stigma, definitely longer than the

transverse cubital ; this latter usually equal to the apical portion of the 1st abscissa of the cubital but sometimes just longer, definitely longer than the upper portion of the basal vein, nearly twice as long as the pigmented portion of the 2nd abscissa of the cubital ; the recurrent just longer than, sometimes about equal to, the transverse cubital ; stigma usually shorter than, sometimes (as in the type) about equal to, the metacarp. *Legs* : hind coxae above basally lightly rugoso-punctate, otherwise smooth or with sparse, fine punctation (degree 1) ; the longer hind tibial spur three-sevenths, and the shorter spur about one-third, the length of the basal joint of the hind tarsus. *Abdomen* : 1st tergite (fig. 3, *m*) in apical half rugose with a median longitudinal impression, medianly strongly tumescent ; 2nd tergite almost entirely smooth, as are the remaining tergites, rather longer than half length of 3rd tergite ; ovipositor sheaths about equal to the hind tarsus.

Length, about 3 mm.

Redescribed from Cameron's type, and from 12 ♀♀, xii.1912, bred at Kheri, India, from lac.

Type in the British Museum.

The type was bred in Dehra Dun, India, from lac (*Tachardia*) obtained from Bishanpur, Saharanpur District, India.

Cocoons unknown.

52. Apanteles importunus, sp. n.

♀. Black ; front legs distally from the apex of the femora, basal half of middle tibiae, middle tarsi, basal third or fourth of hind tibiae, and extreme base of hind tarsal joints (more or less), red testaceous ; palpi pale ; tibial spurs white ; wings hyaline ; costal vein testaceous ; stigma hyaline bordered with brown ; metacard brown, remaining veins colourless.

♂. Agrees with the female except that the front tibiae and tarsi, and middle tarsi, are strongly nigrescent, and that only the basal fourth of the middle tibiae is red testaceous.

♀♂. Agrees well enough in sculpture with my redescription of *A. tachardiae* except as follows : *Propodeon* lightly, often indefinitely, rugose at extreme base, otherwise largely smooth and shining. *Abdomen* : 1st tergite with a faintly indicated, smooth, median tumescence, in apical half indefinitely sculptured, at middle as broad as at base, thence rather sharply constricted to apex ; median length of 2nd tergite half that of 3rd tergite.

Length about 2 mm.

India : Dehra Dun, United Provinces, 3 ♀♀, 8 ♂♂, 12.i–1.ii.1928 (*S. N. Chatterjee*).

Type deposited in the British Museum.

Host : a species of the Pyralid genus *Nephopteryx*, which was defoliating *Cassia fistula*.

Cocoons white, solitary.

53. Apanteles tasmanica, Cam.

Apanteles tasmanica, Cameron, Proc. Linn. Soc. N.S. Wales, xxxvii, 1912, p. 196.

♀. Head with antennae, thorax, all coxae, 1st tergite wholly, remaining tergites largely, and ovipositor sheaths, black ; middle legs from the trochanters, hind trochanters, tegulae, all veins of forewing (except as below), and ventrites largely, red testaceous ; palpi and middle tibial spurs pale ; stigma, metacarp, 1st abscissa of radial, transverse cubital, and pigmented portion of the 2nd abscissa of the cubital, brown ; remaining parts missing.

♂. Black; fore and middle legs from the trochanters, hind trochanters, hind femora (except above and below), basal half of hind tibiae, and tegulae, red testaceous; palpi and tibial spurs pale; stigma and wing veins brown.

♀. *Head* largely finely punctate (degree 1), faintly rugose behind the eyes. *Thorax*: mesonotum with very strong punctation (degree 5); disc of scutellum virtually smooth and shining except at the basal angles, where there are some strong, rather shallow punctures; propodeon strongly and separately punctate (degree 4–5) basally, coarsely rugoso-reticulate apically; areola at apex rugulose, indicated by carinae, medianly and basally smooth and shining without bounding carinae. *Wings*: 1st abscissa of radial rather shorter than the breadth of the stigma, longer than the recurrent, which is just longer than the transverse cubital; this latter somewhat longer than the apical portion of the 1st abscissa of the cubital, nearly twice as long as the pigmented portion of the 2nd abscissa of the cubital, which is definitely longer than the upper portion of the basal vein; stigma shorter than metacarp. *Legs*: hind coxae strongly and separately punctate (degree 4) above basally, outer faces finely punctate (degree 1). *Abdomen*: 1st tergite in shape more or less a regular right-angled parallelogram, possibly a little narrowed at base, 1·5 times as long as broad, medially tumescent, in apical half strongly rugose-reticulate; 2nd tergite hardly broader at apex than at base, rather broader than apex of 1st tergite, median length about a third the breadth of apex of 1st tergite, rather pointed at the middle of apex, smooth save for a few strong punctures (degree 4); 3rd tergite nearly twice as long as the 2nd, almost entirely smooth, as are the remaining tergites; ovipositor sheaths longer than the abdomen.

♂. Agrees with my redescription for the sculpture of the ♀ except as follows: *Thorax*: punctation at the basal angles of the disc of the scutellum virtually absent; propodeon basally impunctate and faintly rugulose, shining, apically rugulose and somewhat shining. *Wings*: 1st abscissa of the radial, the transverse cubital, and the recurrent, more closely approximating in length with one another, but as in the ♀ all shorter than the breadth of the stigma and longer than the apical portion of the 1st abscissa of the cubital. *Legs*: hind tibial spurs subequal, about two-fifths the length of the basal joint of the hind tarsus. *Abdomen*: 1st tergite a regular right-angled parallelogram, shorter than that of the ♀ but narrower, the breadth being three-fifths the length, the breadth of the tergite in the ♂ being about half the length of that of the ♀, medianly somewhat tumescent, in apical half with some strong punctures (degree 5); median length of the 2nd tergite half the breadth of the 1st; 3rd tergite not twice as long as the 2nd.

Length, ♀, 3·0; ♂, 2·5 mm.

Redescribed from a male and a female, both labelled as type.

Type in the British Museum.

The type locality is Launceston, Tasmania.

Host unknown.

Cocoons unknown.

I am not altogether satisfied that, in this instance, the sexes have been correctly associated; the differences in the sculpture of the propodeon and of the 1st tergite are very marked.

54. Apanteles birói, Szép.

Apanteles birói, Szépligeti, Ann. Mus. Nat. Hung., iii, 1905, p. 49.

♀. Black: fore and middle legs (except coxae in each case), hind trochanters, hind femora (except above and below), about basal half of hind tibiae, tegulae, costal veins, abdominal ventrites, and tergites laterally, red testaceous; palpi and tibial spurs pale; stigma brown with a whitish cloud basally; metacarp brown.

♂. Agrees in colour with my redescription of the ♀ except that the middle femora are strongly nigrescent above and below, that the hind trochanters and hind femora are entirely darkened, that the apices of the middle tibiae and of the middle tarsi are occasionally nigrescent, and that the ventrites are normally darker to completely darkened.

♀♂. *Head* for the most part finely and closely punctate (degree 1) ; occiput very faintly and finely rugose, shining, *Thorax* : mesonotum with separated, coarse punctation (degree 5), more finely punctate laterally and anteriorly (degree 4) ; disc of scutellum shining and very sparsely and finely punctate (degree 1) ; propodeon with well separated, strong punctation (degree 3–4) ; areola at extreme apex indicated by carinae, medianly and basally indicated by the propodeon being somewhat sunken and completely devoid of punctation or other sculpture. *Wings* : 1st abscissa of the radial more or less evenly rounded with the transverse cubital and its length hard to determine, apparently rather shorter than the breadth of the stigma, rather longer than the recurrent ; the apical portion of the 1st abscissa of the cubital about twice as long as the upper portion of the basal vein, a little longer than the pigmented portion of the 2nd abscissa of the cubital, equal to, or occasionally somewhat shorter than, the transverse cubital, noticeably shorter than the recurrent, about half as long as the breadth of the stigma ; stigma shorter than metacarp. *Legs* : hind coxae basally above with a few strong punctures, otherwise almost entirely with fine punctation (degree 1) ; the hind tibial spurs subequal, the longer just half the length of the basal joint of the hind tarsus. *Abdomen* : ♀—1st tergite with the sides virtually parallel, about 1·5 times as long as broad, polished and shining, in the apical half with very sparse but strong punctation (degree 4), deeply aciculate at extreme apex, roundly tumescent medianly ; the 2nd tergite entirely smooth and shining, with median length two-fifths, and basal breadth rather more than, breadth of 1st tergite, broader at apex than at base ; 3rd tergite in length about half the breadth of the 1st ; ovipositor sheaths as long as, or rather longer than, the combined lengths of the hind tibia and the basal joint of the hind tarsus ; ♂—1st tergite twice as long as broad at apex, with the sides in apical half virtually parallel, the sides in the basal half converging slightly, so that the apex of the tergite is narrower than the base, sculptured as in the ♀ except that possibly it is even more sparsely punctate ; 2nd tergite impunctate, with median length four-sevenths, and basal breadth rather more than, apical breadth of the 1st tergite, broader at apex than base ; 3rd tergite nearly as long as the apical breadth of the 1st tergite (12 : 14).

Length, 3 mm.

Redescribed from 2 ♀♀, 8 ♂♂, all labelled as type, which were kindly lent me by Dr. Biró.

Type series in the National Museum, Hungary, which however has presented the British Museum with a pair of specimens.

The type locality is Sydney, New South Wales.

Host unknown.

Cocoons unknown.

55. Apanteles bisulcata, Cam.

Apanteles bisulcata, Cameron, Spol. Zeylan., vi, pt. 21, 1909, p. 42.

♀. Agrees well enough, both in colour and sculpture, with my redescription of *A. tachardiae*, except that the 2nd tergite is somewhat shorter, and that the sheaths of the ovipositor are not longer than the hind tibiae. Differs from *A. machaeralis* notably in the distance between the hind ocelli, this distance in *bisulcata* being less than the distance between a hind ocellus and the eye, in *machaeralis* being greater than the distance between a hind ocellus and the eye.

Length, 2·25 mm.

Redescribed from the type, which is in the British Museum.

The type locality is Weligama, Ceylon.

Host. Bred from the Pterophorid, *Steganodactyla* (now *Ochyrotica*) *concursa*, Wlsm.

Cocoons. The coccoon is snow-white, longish oval, and is spun, solitary, on the leaf of the food-plant.

56. Apanteles machaeralis, sp. n.

♀. Agrees in colour with my redescription of *A. tachardiae*, except that the distal portion of the middle tibiae is rarely, if ever, at all darkened.

♂. Agrees in colour with the ♀ except that the middle tibiae are commonly nigrescent, that only the basal third of the hind tibiae is red testaceous, and that the hind tarsal joints are red testaceous only at the extreme bases.

♀♂. Agrees well enough in sculpture with my redescription of *A. tachardiae* except as follows:—*Head*: vertex, frons, and frontal orbits punctate like the face. *Thorax*: mesonotum with very close and shallow punctation (degree 2). *Wings*: stigma about equal to metacarp; 1st abscissa of the radial with length rather variable, commonly very rounded, so that its point of junction with the transverse cubital is difficult to determine. *Legs*: the rugosity on the hind coxae basally above but lightly if at all indicated. *Abdomen*: 1st tergite (fig. 3, *h*), with the median longitudinal excavation not so definitely shown; 2nd tergite rather dull and faintly roughened in the ♀; ovipositor sheaths just shorter than the hind tibiae.

The distance between the hind ocelli somewhat greater than the distance between a hind ocellus and the eye.

Length, about 2·5–2·75 mm.

India: Dehra Dun, United Provinces, 6 ♀♀, 2 ♂♂, 6–21.x.1926, 22.xi.1926, 13.xii.1926, 7.ix.1927 (type), 7.ix.1927 (*S. N. Chatterjee*); Nilambur, Madras, 2 ♀♀, 2 ♂♂, 18.v.1927, 25–26.v.1927, 4.vi.1927 (*S. N. Chatterjee*); Rahatgaon, Hoshangabad, Central Provinces, 10 ♀♀, 27 ♂♂, 3–30.vii.1926, 1–26.viii.1926, 17–29.ix.1926, 1.x.1926, 30.x.1926.

Type deposited in the British Museum.

Host. Bred from larvae of the Pyralid, *Pyrausta machaeralis*, Walk.

Cocoons white, solitary.

57. Apanteles significans, Walk.

Microgaster significans, Walker, Ann. Mag. Nat. Hist., (3) v, 1860, p. 308.

♂. Black; the front legs from the coxae to the basal half of the femora, red; front legs distally from the middle of femora, middle tibiae and tarsi, basal third of hind tibiae, and costal vein, red testaceous; palpi and tibial spurs pale; stigma hyaline bordered with brown; metacarp brown.

♂. *Thorax*: mesonotum and disc of scutellum strongly and completely rugoso-punctate; propodeon with the areola very strongly marked and closed basally; costulae strong. *Wings*: 1st abscissa of radial 1·3 times as long as the breadth of the stigma, 2·5 times as long as the transverse cubital, nearly three times as long as the pigmented portion of the 2nd abscissa of the cubital; stigma shorter than metacarp. *Legs*: hind coxae apparently but finely punctate (degree 1–2); the longer hind tibial spur half, and the shorter spur rather less than a third, the length of the basal joint of the hind tarsus. *Abdomen*: 1st tergite twice as long as its basal breadth, regularly tapering somewhat to apex, medianly tumescent, in apical half rugose;

2nd tergite twice as broad at apex as at base, with median length four-fifths of the basal breadth, largely smooth and shining, towards apex apparently somewhat sculptured.

Length, 3 mm.

Redescribed from the type, which is in the British Museum.

The type locality is Ceylon.

Host unknown.

Cocoons unknown.

58. Apanteles hemitheae, sp. n. ♀♂

♀♂. Black; legs with the femora, tibiae, and tarsi (except as below), scape, basal joints of the flagellum more or less (particularly beneath), and costal veins more or less, red testaceous; extreme apices of hind tibiae, and hind tarsi, slightly darkened; flagellum brown; palpi and tibial spurs pale; stigma, in ♀ brown with a pale cloud basally, in ♂ hyaline margined with brown.

♀. *Head*: face and frons strongly, rather closely punctate (degree 3–4); vertex and occiput rugose, or extremely closely, coarsely punctate (degree 3–4); clypeus only very finely punctate (degree 1). *Thorax*: mesonotum very strongly, closely punctate (degree 5); disc of scutellum with very well separated, strong but shallow punctation; propodeon, except possibly basally, where it is more or less indefinitely shallowly punctate, almost entirely smooth and shining, save for the very strong carinae of the costulae and of the areola; areola open at extreme base. *Wings*: 1st abscissa of the radial and the recurrent of equal length, just shorter than the breadth of the stigma, rather longer than the transverse cubital; the apical portion of the 1st abscissa of the cubital shorter than the transverse cubital, longer than the pigmented portion of the 2nd abscissa of the cubital, this latter being just half the length of the transverse cubital but longer than the upper portion of the basal vein; stigma shorter than metacarp. *Legs*: hind coxae extremely finely and sparsely punctate, except basally above, where the punctures are more definite, sometimes being quite strong but shallow; the longer hind tibial spur half, and the shorter spur about a third, the length of the basal joint of the hind tarsus. *Abdomen*: 1st tergite with the apical width equal to the median length, definitely broader at apex than at base, in apical two-thirds strongly rugosely reticulate and with a median longitudinal carina; 2nd tergite 2·5 times as broad at apex as long down middle, just broader at apex than at base, the breadth of the base equalling, or a little greater than, the apical breadth of the 1st tergite, strongly rugose or rugosely reticulate; 3rd tergite in shape and size much as the 2nd, more weakly rugose, and often only rugose at extreme base; ovipositor sheaths shorter than basal joint of the hind tarsus.

♂. Agrees with the description of the ♀ except as below: *Thorax*: mesonotum with the punctation not quite so closely placed as in the ♀. *Wings*: 1st abscissa of the radial appears to be more evenly rounded with the transverse cubital. *Abdomen*: 1st tergite not so definitely sculptured as in the ♀ save for the median longitudinal carina; 2nd and 3rd tergites in shape and sculpture variable, the 3rd occasionally entirely smooth, the 2nd varying between twice and three times as broad as long, and broader at apex than at base.

Length, 2 mm.

Federated Malay States: Kuala Lumpur, 3 ♀♀, 3 ♂♂, 6.vi.1922 (type), 21–31.v.1922, 25.vi.1921 (*G. H. Corbett & B. A. R. Gater*).

Type deposited in the British Museum.

Host. Recorded as parasitic on the Geometrid, *Hemithea costipunctata*, Moore.

Cocoons greenish white (Oberthur No. 15).

59. Apanteles hyposidrae, sp. n. ♀♂

♀♂. Black ; the forelegs (except coxae), middle legs distally from about the middle of the femora, and basal two-thirds of the hind tibiae, red testaceous ; front femora slightly darkened at extreme base ; hind tarsi and apical third of hind tibiae darkened slightly ; hind femora and scape nigrescent to black ; flagellum dark brown ; stigma and metacarp brown ; costal veins basally testaceous.

♀♂. Agrees with my redescription of the sculpture of *A. expulsus* except as follows :—*Thorax* : disc of scutellum impunctate, smooth, and shining, save for punctation (degree 3) on the basal angles and laterally. *Wings* : 1st abscissa of the radial evenly rounded with, and hardly differentiated from, the transverse cubital ; recurrent rather variable but usually just shorter than, or equal to, the breadth of the stigma ; pigmented portion of the 2nd normally equal to the apical portion of the 1st abscissa of the cubital ; stigma shorter than metacarp. *Abdomen* : 1st tergite (fig. 3, *j*) in apical half more or less rugosely striate with some strong punctures ; 2nd tergite more often very indefinitely sculptured in apical half, but occasionally rather indefinitely, very weakly, longitudinally striate, ovipositor sheaths definitely shorter than the basal joint of the hind tarsus.

Length, 2 mm.

JAVA : Midden, 23 ♀♀, 5 ♂♂, 1924 (*R. Menzel*).

Type deposited in the British Museum.

Host. Recorded as parasitic on a species of the Geometrid genus *Hyposidra*.

Cocoons pure white, heaped in masses together and covered with masses of pure white fluffy hair. It is recorded by Menzel that, when this species occurs in any number, small bushes of *Mimosa* are so covered with these white hairy masses as to give the impression of snow.

60. Apanteles expulsus, Turn.

Apanteles expulsus, Turner, Trans. Ent. Soc. London, 1918, p. 346.

♀♂. Black; legs with the femora tibiae, and tarsi (except as below), scape (except at extreme apex), and costal veins, red testaceous ; hind tarsi and apical fourth of the hind tibiae slightly darkened ; palpi and tibial spurs pale ; flagellum, metacarp, and stigma, brown, the latter with a small pale cloud basally.

♀♂. *Head* mostly finely rugose ; face exceedingly finely punctate (degree 1). *Thorax* : mesonotum with widely spaced, strong punctation (degree 4) ; disc of scutellum for the most part impunctate, smooth, shining, very occasionally with one or two fairly strong punctures towards the basal angles or laterally ; propodeon shining, unsculptured save for the strong carinae of the costulae and of the areola ; areola open at extreme base. *Wings* : 1st abscissa of the radial just longer than the recurrent, just shorter than the breadth of the stigma, longer than the transverse cubital with which latter it is more or less evenly rounded ; the apical portion of the 1st abscissa of the cubital shorter than the transverse cubital, just longer than the pigmented portion of the 2nd abscissa of the cubital, this latter being longer than half the length of the transverse cubital and longer than the upper portion of the basal vein ; stigma shorter than metacarp. *Legs* : hind coxae on outer faces apparently impunctate, basally above with a few punctures (degree 3) ; the longer hind tibial spur if anything just less than half, and the shorter spur about a third the length of the basal joint of the hind tarsus. *Abdomen* : 1st tergite (fig. 3, *k*) strongly rugose, somewhat tumescent medianly, generally with only an indication of a median longitudinal carina ; 2nd tergite strongly rugose ; 3rd and succeeding tergites invariably smooth ; ovipositor sheaths about as long as, or rather shorter than, the basal joint of the hind tarsus.

Length, 2 mm.

Redescribed from the typical series of 3 ♀♀ and 1♂; and from 15 ♀♀, 2 ♂♂ from Lalomanu, Upolu I., Samoan Is., xi.1924 (*P. A. Buxton & G. H. Hopkins*).

Type in the British Museum.

The type locality is Natova, Fiji.

Host. Recorded by Turner as the Noctuid, *Anticarsia irrorata*, F.; there is no host record for the Samoan series.

Cocoons pure white, heaped indiscriminately together.

61. Apanteles mendañae, sp. n.

♀. Agrees with my redescription of the colour of *A. expulsus* except that the scape is darker, that nearly the apical half of the hind tibiae is decidedly darkened, and that the hind femora are slightly but distinctly darkened.

♀. Agrees with my redescription of the sculpture of *A. expulsus* except as follows: *Head* finely rugose to finely punctate. *Thorax*: punctation of the mesonotum even more widely spaced, sometimes very ill defined. *Wings*: the 1st abscissa of the radial slightly, but definitely, more angled with the transverse cubital than in *A. expulsus*.

Length, 2 mm.

Marquesas Is.: Hiva-oa, 5 ♀♀, and 4 specimens of sex indeterminable through damage, undated (*L. E. Cheesman*).

Type in the British Museum.

Host unknown.

Cocoons as in *A. expulsus*.

62. Apanteles caniae, sp. n.

♀. Black; legs rather pale red testaceous, with the coxae black, and the apex of hind tibiae and the hind tarsi (somewhat) slightly darkened; palpi and tibial spurs pale; scape dark red to black; flagellum dark red-brown, but sometimes pale beneath; costal veins, metacarp, and stigma, red-brown.

♀. *Head* mostly very finely rugose; face very finely punctate (degree 1). *Thorax*: mesonotum with definite, rather shallow punctation (degree 3–4); disc of scutellum mostly impunctate and shining, but with numerous, shallow, indefinite punctures laterally (degree 1–3), with a few such punctures discally; propodeon: costulae and basal lateral margins of the areola very strong, formed as a strong basal transverse ridge on each side, the apical lateral margins of the areola being definitely present but definitely weaker; the propodeon otherwise irregularly and coarsely sculptured, particularly in the neighbourhood of the carination. *Wings*: 1st abscissa of the radial equal to the transverse cubital, definitely longer than the apical portion of the 1st abscissa of the cubital, rather shorter than the recurrent, which latter is about equal to the breadth of the stigma; stigma apparently shorter than metacarp. *Legs*: hind coxae on outer faces with only a few extremely weak punctures (degree 1), basally above possibly rather more strongly and closely punctate; the longer hind tibial spur rather longer than half, and the shorter spur two-fifths, the length of the basal joint of the hind tarsus. *Abdomen*: 1st tergite (fig. 3, *b*) in about the middle third closely rugose, in about the apical third finely longitudinally striate at the sides, in the middle at apex with a small, unsculptured, shining area; in addition there are a few fairly strong punctures which on account of the other sculpture are not very evident; 2nd tergite at sides with fine but very definite longitudinal striae, in the middle more or less smooth and shining at base, with very definite transverse striae at apex; ovipositor sheaths shorter than the hind femora.

Length, 2·5 mm.

JAVA: 16 ♀♀, vi.1922 (*R. Menzel*).

Type deposited in the British Museum.

Host. Recorded as parasitic on the Limacodid, *Cania bilinea*, Walk.

Cocoons unknown.

63. Apanteles heterusiae, sp. n.

♀♂. Black; femora, tibiae and tarsi of the four anterior legs, hind femora, and hind tibiae (except their apices), red testaceous; apices of hind tibiae and the hind tarsi darkened; palpi and tibial spurs pale; antennae dark brown; costal veins, metacarp, and stigma pale brown to testaceous.

♀. *Head* apparently for the greater part extremely finely rugose. *Thorax*: mesonotum with very well separated, strong punctation (degree 4); disc of scutellum smooth, shining, and impunctate, save for some very fine and sparse, more or less evenly spaced, punctures (degree 1–2); propodeon with the carinae of the costulae and of the areola strongly marked, otherwise virtually unsculptured save indefinitely at apex; areola shining, open at extreme base. *Wings*: 1st abscissa of radial, the recurrent, and the breadth of the stigma, all equal, only just longer than (possibly equal to) the transverse cubital; apical portion of the 1st abscissa of the cubital rather longer than half the recurrent; the pigmented portion of the 2nd abscissa of the cubital rather longer than half the transverse cubital, just longer than the upper portion of the basal vein; stigma shorter than metacarp; venation rather variable. *Legs*: hind coxae extremely finely and rather sparsely punctate (degree 1); hind tibial spurs subequal and about a third the length of the basal joint of the hind tarsus. *Abdomen*: 1st tergite a little broader at apex than at base, the median length 1·16 times the apical width, which latter is very nearly the widest part, medianly rugosely tumescent with a strong median longitudinal carina running from the tumescence half way to apex of tergite, apical half of tergite carinate, or in the smaller forms nearly smooth save for a few weak longitudinal carinae; 2nd tergite with its apical width equal to median length of the 1st and 3·5 times its own length, definitely striate longitudinally, with a small, raised, median, smooth, shining area; 3rd tergite about 1·5 times as long as the 2nd, smooth and shining, as are the succeeding tergites; ovipositor sheaths about equal to or slightly longer than the hind femora.

♂. Agrees with the ♀ except as follows:—*Abdomen*: median length of 1st tergite approaching 1·5 times its apical width, rather longer than apical width of 2nd tergite, which is three times the median length of 2nd tergite; 3rd tergite rather less than 1·5 times as long as the 2nd.

Length, 1·75–2·5 mm.

CEYLON: Madulsima, 13 ♀♀ (one the type), 17 ♂♂, 25.viii.1922 (*J. C. Hutson*); Badulla, 1 ♀, 3 ♂♂, 8.ix.1920 (*J. C. Hutson*).

Type deposited in the British Museum.

Host. Recorded by Mr. Hutson as bred from the Zygaenid (Chalcosiinae), *Heterusia cingala*, Moore, on tea.

Cocoons unknown.

64. Apanteles prodeniae, Vier.

Apanteles (*Apanteles*) *prodeniae*, Viereck, Proc. U.S. Nat. Mus., xlii, no. 1888, 1912, p. 139.

♀. Black; all femora, tibiae, and tarsi red testaceous, except that the hind tarsi and the apices of the hind tibiae are darkened somewhat; antennae dark red-brown to black; palpi and tibial spurs pale; costal veins testaceous; stigma light brown.

♀. *Head*: vertex and occiput largely extremely finely rugose; face evenly punctate (degree 3). *Thorax*: mesonotum with well separated, more or less evenly spaced punctures (degree 4–5); disc of scutellum largely, but rather sparsely, punctate (degree 3); areola large, nearly quadrate, open at the extreme base, its carinae and the costulae strong; propodeon otherwise unsculptured, shining. *Wings*: the breadth of the stigma less than the length of the 1st abscissa of the radial, greater than the length of the transverse cubital, this latter equal to the recurrent; the apical portion of the 1st abscissa of the cubital shorter than the recurrent, about half the length of the 1st abscissa of the radial, longer than the pigmented portion of the 2nd abscissa of the cubital, which latter equals the upper portion of the basal vein; stigma shorter than metacarp. *Legs*: hind coxae on outer faces apparently impunctate; the longer hind tibial spur half, and the shorter spur about two-fifths, the length of the basal joint of the hind tarsus. *Abdomen*: 1st tergite (fig. 3, *g*) medianly tumescent and lightly rugose, towards apex smoother and with a few strong punctures, at apex smooth; 2nd tergite virtually unsculptured; ovipositor sheaths shorter than the hind femora.

Length, 2·5 mm.

Redescribed from a ♀ cotype presented by Dr. Gahan, through the Imperial Bureau of Entomology, to the British Museum, and from 11 ♀♀, 9.vi.1909, bred from the same host in the same locality as the type series.

The type locality is Bangalore, Mysore, India.

Host. Larvae of the Noctuid, *Prodenia litura*, F. (= *littoralis*, Boisd.).

Cocoons unknown.

65. Apanteles opacus, Ashm.

Urogaster opacus, Ashmead, Proc. U.S. Nat. Mus., xxix, no. 1416, 1905 (1906), p. 118.

♀. Black; the four anterior legs (except the coxae), hind trochanters and trochantines, about basal fourth of hind femora, basal half of hind tibiae, hind tarsal joints basally, and basal ventrites, red testaceous; costal veins basally, palpi, and tibial spurs, pale; stigma and wing veins brown.

♀. *Head* mostly punctate (degree 1–2). *Thorax*: mesonotum rather irregularly, strongly punctate (degree 4), with rugose fine striae along the lines of the notauli; disc of the scutellum shining, with shallow, rather indefinite but strong, punctures (degree 4–5); propodeon with the carinae of the areola and costulae very strongly marked, the intermediate areae shining, and unsculptured save for some rather strong secondary carination; the areola is strongly V-shaped. *Wings*: the 1st abscissa of the radial rather longer than the recurrent, shorter than the breadth of the stigma, which is twice as broad as the length of the transverse cubital; the apical portion of the 1st abscissa of the cubital apparently longer than the transverse cubital, definitely longer than the pigmented portion of the 2nd abscissa of the cubital, which latter about equals the upper portion of the basal vein; stigma shorter than metacarp. *Legs*: hind coxae somewhat shining, apparently completely covered with indefinite, extremely shallow, evenly spaced punctures; the longer hind tibial spur half, and the shorter spur a third, the length of the basal joint of the hind tarsus. *Abdomen*: 1st tergite as broad at base as at apex, with greatest breadth in apical third, about 1·75 times as long as greatest breadth, about 2·3 times as long as apical breadth, in apical two-thirds longitudinally rugose or rugosely striate, strongly tumescent medianly, with immediately beyond this tumescence an elongate, somewhat excavated area reaching almost to the apex of the tergite, where medianly there is a small, smooth, shining, raised, semicircular area; 2nd tergite in apical half indefinitely aciculate; ovipositor sheaths equal to or just longer than the hind femora.

Length, 3 mm.

Redescribed from a single female determined as *opacus* by Dr. Gahan, and presented by him, through the Imperial Bureau of Entomology, to the British Museum.

The type locality is Manila.

Host unknown.

Cocoons unknown.

66. Apanteles parasae, Rohw.

Urogaster philippinensis, Ashmead, J.N.Y. Ent. Soc., xii, 1904, p. 19 (*nec Apanteles philippinensis*, Ashm. 1904).

Apanteles parasae, Rohwer, Treubia, iii, 1922, p. 54.

♀♂. Black; the fore and middle legs (except the middle femora basally), basal half of hind tibiae, and basal sternites, red testaceous; hind femora strongly, apical half of hind tibiae, and hind tarsi, darkened; palpi and tibial spurs pale; antennae dark red-brown; costal veins testaceous; stigma brown.

♀♂. *Head*: face extremely finely punctate (degree 1); occiput largely indefinitely finely rugose. *Thorax*: mesonotum with well marked and well separated but rather shallow punctation (degree 4); disc of scutellum shining, with scattered very sparse punctures (degree 3); propodeon shining and unsculptured save for the very strong carinae of the costulae and areola; the areola open at extreme base. *Wings*: the recurrent equal to or possibly rather less than the breadth of the stigma, definitely less than the 1st abscissa of the radial, longer than the transverse cubital, this latter longer than the 1st abscissa of the cubital; pigmented portion of the 2nd abscissa of the cubital half the length of the transverse cubital, equal to or rather less than the upper portion of the basal vein; stigma shorter than metacarp. *Legs*: hind coxae on outer faces largely smooth, shining, and impunctate, otherwise very finely punctate (degree 1–2); hind tibial spurs subequal, about half the length of the basal joint of the hind tarsus. *Abdomen*: 1st tergite (fig. 3, *n*) medianly dull with a rugose tumescence, apically shining and almost smooth; 2nd tergite virtually unsculptured; ovipositor sheaths about equal to the hind femur, but possibly just longer.

Length, 2 mm.

Redescribed from a female cotype of both *A. parasae* and of *U. philippinensis*, both presented by Dr. Gahan, through the Imperial Bureau of Entomology, to the British Museum, and from 2 ♀♀, 1 ♂, and 2 of unknown sex, iii.1927 (*S. Leefmans*), bred in the same locality as and from the same host as *A. parasae*.

The type locality of *U. philippinensis* is Manila, and of *A. parasae* Buitenzorg, Java.

Host of *A. parasae*, a larva of the Limacodid genus, *Parasa*; of *U. philippinensis*, unknown.

Cocoons unknown.

It was Dr. Gahan who, in his draft key of the Oriental species of *Apanteles* in the United States National Museum, originally suggested that *A. parasae* and *U. philippinensis* were synonymous.

67. Apanteles bambusae, sp. n. ♀♂

♀♂. Agrees in colour well enough with my redescription of *A. parasae* except that the basal ventrites are more usually dark red; in the ♂, the legs are possibly rather darker than in *parasae*.

♀♂. *Head*: face finely punctate (degree 2); occiput as in *parasae*. *Thorax*: mesonotum as in *parasae*; disc of scutellum polished and shining, with only a few

punctures (degree 3), commonly impunctate ; carinae of the costulae and of the areola definitely present but rather weak, occasionally almost obsolete ; propodeon otherwise generally indefinitely sculptured, occasionally with definite punctation basally, often (particularly in the males) entirely smooth. *Wings* : the breadth of the stigma, the length of the 1st abscissa of the radial, of the transverse cubital, and of the recurrent, all about equal, but there is much variation, the 1st radial often being definitely longer than the transverse cubital ; the apical portion of the 1st abscissa of the cubital always very definitely shorter than the transverse cubital, definitely longer than the upper portion of the basal vein, which latter equals or is somewhat greater than the pigmented portion of the 2nd abscissa of the cubital; stigma shorter than metacarp. *Legs* : hind coxae basally above occasionally strongly punctate, commonly with a group of rather indefinite punctures (degree 3–4), often however, particularly in the males, like the outer faces which are shining and extremely sparsely punctate (degree 1) or impunctate. *Abdomen* : 1st tergite medianly slightly tumescent and lightly rugose, apically (except in the males) very definitely striate to extreme apex, with the sides parallel, nearly twice as long as broad ; 2nd tergite indefinitely sculptured, in the ♀, with median length half the breadth of base, the 2nd suture strongly rounded so that the length of the 2nd tergite at the sides is definitely less than that medianly, in the ♂, with median length two-thirds basal breadth, the 2nd suture straight and the breadth of the 2nd tergite equal to the length of the 1st tergite ; 3rd and succeeding tergites largely impunctate, highly polished and shining ; ovipositor sheaths slightly shorter than the hind femora.

Length, 2 mm.

INDIA : Pusa, 4 ♀♀, 3 ♂♂, 22.xii.1916 (type), 16–24.x.1916.

Type deposited in the British Museum.

Host. Recorded as parasitic on the Cosmopterygid, *Cosmopteryx bambusae*, Meyr.

Cocoons unknown.

This species is inclined to be flattened, thus in general appearance much resembling *A. flavipes*, Cam.

68. Apanteles agilis, Ashm.

Pseudapanteles agilis, Ashmead, Proc. U.S. Nat. Mus., xxviii, no. 1413, 1905, p. 969.

Apanteles hidaridis, Rohwer, Treubia, iii, 1922, p. 54.

♀♂. Black ; the four anterior legs (except the coxae), hind femora at extreme apex, and basal half of hind tibiae, red testaceous ; middle femora often darkened somewhat basally ; hind femora, apical half of hind tibiae, and hind tarsi, strongly darkened ; palpi and tibial spurs pale ; antennae dark brown ; stigma and wing veins brown ; wings slightly infumated evenly throughout.

♀. *Head* : face finely punctate (degree 1) ; vertex and occiput finely rugose. *Thorax* : mesonotum with separated punctation (degrees 3 and 4) ; disc of scutellum virtually impunctate, smooth, and shining, save along the lateral margins ; propodeon smooth, shining, and unsculptured, save for the strong carinae of the areola and the costulae ; areola more or less open at extreme base. *Wings* : the 1st abscissa of the radial and the transverse cubital not differentiated ; the apical portion of the 1st abscissa of the cubital and the pigmented portion of the 2nd abscissa equal, longer than the upper portion of the basal vein, their combined lengths equal to the breadth of the stigma, which latter is somewhat greater than the length of the recurrent ; stigma shorter than metacarp. *Legs* : hind coxae on outer faces virtually impunctate, shining, basally above with indications, and occasionally a small group, of more definite punctures (degree 2–3) ; the longer hind tibial spur three-fifths, and the shorter spur rather more than two-fifths, the length of the basal joint of the hind

tarsus. *Abdomen*: 1st tergite (fig. 3, *l*) not or barely tumescent medianly, in basal half smooth and shining, in apical half shining, with a number of strong, widely separated punctures (degree 4), at extreme apex striate in lateral thirds; 2nd tergite smooth and unsculptured; ovipositor sheaths as long as or longer than hind tibia.

Length, 2 mm.

Redescribed from a single female cotype of *hidaridis* presented by Dr. Gahan, through the Imperial Bureau of Entomology, to the British Museum, and from 11 ♀♀, 1 ♂, xii.1924 (*Leefmans*), which were bred from the same host, and in the same locality, as the cotype before me.

The type locality of *Pseudapanteles agilis* is Manila; that of *A. hidaridis* is given by Rohwer as Padang, Sumatra, although the cotype before me is labelled Buitenzorg, Java.

Host. Rohwer records that his series was bred from a larva of the Hesperiid genus, *Hidari*; Leefmans now records the host as *Hidari irava*, Moore. There was no host record for *P. agilis*.

Cocoons. Leefmans (Med. Inst. voor Plantenziekten, xxxv, 1919, p. 25) gives a photograph of the cocoons, and says that they are white and are generally located on the leaves of the coconut tree close to the host larva. It will be seen that the cocoons may be solitary or grouped together in little clusters.

I have not seen a specimen of *P. agilis*, but am synonymising *hidaridis* under *agilis* on the authority of Dr. Gahan.

69. Apanteles stantoni, Ashm.

Urogaster stantoni, Ashmead, J.N.Y. Ent. Soc., xii, 1904, p. 20.

♀♂. Black; scape largely, and legs (except coxae), bright red to yellow-red testaceous, except that the hind tarsi are slightly, and the apices of the hind tibiae decidedly, darkened; flagellum dark red-brown; palpi and tibial spurs pale; costal veins testaceous; stigma and metacarp brown.

♀. *Head*: face punctate (degree 2); vertex and occiput finely rugose. *Thorax*: mesonotum closely punctate (degrees 3 and 4); disc of scutellum virtually impunctate, or obscurely punctate along lateral margins and basally at sides; propodeon (except possibly basally) unsculptured save for the strong carinae of the areola and costulae; areola open at extreme base. *Wings*: the breadth of the stigma rather less than the length of the 1st abscissa of the radial, greater than the length of the recurrent, which latter is longer than the transverse cubital; apical portion of the 1st abscissa of the cubital equal to the transverse cubital, twice as long as the pigmented portion of the 2nd abscissa of the cubital, which latter is about equal to the upper portion of the basal vein; stigma shorter than metacarp. *Legs*: hind coxae highly shining, basally above very indefinitely punctate; the longer hind tibial spur about half, and the shorter spur about a third, the length of the basal joint of the hind tarsus. *Abdomen*: 1st tergite more or less parallel-sided, not at all narrowed at apex, slightly tumescent medianly, rugulosely reticulate or striate, often smooth and shining at extreme apex; 2nd tergite smooth and shining, often strongly but finely striate; ovipositor sheaths shorter than or about equal to hind tarsus.

♂. Agrees with the redescription of the female except that the 1st tergite is evenly, very slightly narrowed to apex.

Length, 2–3 mm.

Redescribed from a single female cotype presented by Dr. Gahan, through the Imperial Bureau of Entomology, to the British Museum, and from 8 ♀♀, 4 ♂♂, Rahatgaon, Hoshangabad, Central Provinces, India, viii.1926 (*S. N. Chatterjee*); 2 ♀♀, 11 ♂♂, Nilambur, Madras, ix.1925 (*S. N. Chatterjee*); 8 ♀♀, 20 ♂♂, Dehra Dun,

United Provinces, x.1925 (*R. R. Singh*) ; 7 ♀♀, 1 ♂, Dehra Dun, viii.1925 (*J. C. M. Gardner*) ; 7 ♀♀, 1 ♂, Dehra Dun, x–xi.1926 (*S. N. Chatterjee*) ; Kuala Lumpur, Malay Peninsular, 6 ♀♀, 1 ♂, 16.ix.1924 (*G. H. Corbett & B.A. R. Gater*), 10 ♀♀, 4 ♂♂, 12.xii.1926 (*G. H. Corbett*).

The type locality is given as Manila.

Host of the type series, unknown ; of the above Indian series, the Pyralid, *Margaronia laticostalis*, Guen. ; of the first Malayan series, *Margaronia glauculalis*, Guen. ; and of the second Malayan series, the Eucosmid, *Argyroploce codonectis*, Meyr.

Cocoons of the type series, unknown ; of the Indian series, white, solitary ; of the Malayan series, unknown.

The cotype before me is an immature specimen. The Indian and Malayan series exhibit considerable variation, in the males, in the depth of colour of the scape and hind femora, which are often considerably darkened ; in the females, in the sculpture of the 2nd tergite.

Preparations were made of the antennae of the two Malayan series ; no differences were noted in the respective arrangements of the flagellar sensoria.

70. **Apanteles taragamae,** Vier.

Apanteles (*Apanteles*) *taragamae*, Viereck, Proc. U.S. Nat. Mus., xlii, no. 1888, 1912, p. 140.

Apanteles (*Apanteles*) *plusiae*, Viereck, *op. cit*, xliv, no. 1968, 1913, p. 557.

Apanteles homonae, Rohwer, Treubia, iii, 1922, p. 53.

♀. Black ; the apical two-thirds of the front femora, the apical third of the middle femora, the front and middle tibiae and tarsi, basal two-thirds of the hind tibiae, and the hind tarsi, bright yellow-red testaceous ; palpi and tibial spurs pale ; basal ventrites dark red ; costal veins testaceous ; stigma hyaline, narrowly bordered with brown.

♀. *Head* : face sparsely and finely punctate (degrees 1 and 2) ; vertex and occiput definitely finely rugose. *Thorax* : mesonotum, broadly along the lines of the notauli closely and finely rugose-reticulate, otherwise with close, rather shallow punctures (degree 3) ; disc of scutellum impunctate, smooth, and shining, save for some indefinite punctation along the lateral margins ; propodeon shining, apparently unsculptured (at most indefinitely sculptured) save for the strong carinae of the areola and costulae ; areola open at extreme base. *Wings* : the recurrent just a little longer than the 1st abscissa of the radial, which is just a little longer than the transverse cubital ; the apical portion of the 1st abscissa of the cubital just a little shorter than the transverse cubital, definitely shorter than the recurrent, rather more than twice as long as the pigmented portion of the 2nd abscissa of the cubital, which latter is very definitely shorter than the upper portion of the basal vein, as this is unusually long, the parastigma being obsolete ; stigma apparently shorter than metacarp. *Legs* : hind coxae on outer faces only with sparse, fine punctation (degree 1) ; basally above with stronger punctures (degree 3) ; the longer hind tibial spur half, and the shorter spur rather less than a third, the length of the basal joint of the hind tarsus. *Abdomen* : 1st tergite medianly rugose and strongly tumescent, at extreme apex in the middle with a smooth shining area ; 2nd tergite virtually unsculptured ; ovipositor sheaths about as long as the hind tarsus.

Length, 3 mm.

Redescribed from a single female cotype of *A. homonae* presented by Dr. Gahan, through the Imperial Bureau of Entomology, to the British Museum. I have not

seen specimens of either *A. taragamae* or *A. plusiae*, the type series of which are in Washington ; Dr. Gahan, however, has stated definitely that it is his opinion that these three species are synonymous.

The type locality of both *A. taragamae* and *A. plusiae* is given as Bangalore, Mysore, India ; that of *A. homonae* is Tjiapoes, near Buitenzorg (700 m.), Java.

Hosts of *taragamae*, larvae of the Lasiocampid, *Taragama dorsalis*, Moore ; of *plusiae*, the Noctuid, *Plusia agramma*, Guen., which, according to Hampson, is a synonym of *Phytometra peponis*, F. ; of *homonae*, the Tortricid, *Homona coffearia*, Nietner.

Cocoons. Leefmans (Treubia, iii, 1922, p. 57) records that the cocoons of *homonae* are white, and 5 mm. long by 1·5 mm. in width ; otherwise cocoons unknown.

71. Apanteles platyedrae, sp. n. ♀

♀♂. Black ; forelegs distally from the middle of the femora, middle tibiae and tarsi, middle femora at extreme apices, and basal quarter of hind tibiae, red testaceous ; palpi and tibial spurs pale ; costal veins, stigma, and metacarp dark brown ; other wing veins brown.

♀♂. *Head* : face finely punctate (degree 1) ; occiput with separated, coarsely indefinite punctation. *Thorax* : mesonotum anteriorly with separated, strong punctation (degree 3), posteriorly with the punctures very definitely more widely spaced and stronger (degrees 4 and 5), the interspaces entirely smooth and highly polished and shining ; disc of scutellum entirely smooth, highly polished and shining ; propodeon basally largely rugose, apically virtually unsculptured, the areola, which is open at extreme base, not entirely devoid of indefinite punctures ; carinae of the areola and costulae strong. *Wings* : 1st abscissa of the radial and the recurrent equal, just shorter than the breadth of the stigma ; the apical portion of the 1st abscissa of the cubital and the pigmented portion of the 2nd abscissa equal, about half the length of the recurrent, just shorter than the transverse cubital ; stigma shorter than metacarp. *Legs* : hind coxae on outer faces, and basally above, almost entirely smooth, highly polished and shining. *Abdomen* : 1st tergite in the ♀ more or less parallel-sided, and not or hardly constricted at the apex, longitudinally striate to extreme apex, medianly somewhat tumescent, in the ♂ definitely somewhat converging to apex, medianly somewhat tumescent and rugose, in apical third almost entirely smooth and shining save for one or two strong punctures ; 2nd tergite, in the ♀ strongly transverse, in the lateral thirds definitely longitudinally striate, medianly smooth, in the ♂ not so strongly transverse, entirely smooth and shining ; succeeding tergites smooth and shining ; ovipositor sheaths considerably longer than the hind tarsus.

Length, ♀ 2 mm., ♂ about 1·75 mm.

Fiji : Siga-Toka, 2 ♀♀, 1 ♂, x.1927 (*H. W. Simmonds*).

Type deposited in the British Museum.

Hosts. Recorded as a larval parasite of both the Gelechiid, *Platyedra gossypiella*, Saund., and of the Erechthiid, *Decadarchis heterogramma*, Meyr.

Cocoons unknown.

72. Apanteles hasorae, sp. n. ♀

♀♂. Black ; the four anterior legs (except their coxae), extreme apices of hind femora, and hind tibiae basally, red testaceous ; hind tibiae apically, and hind tarsi, darkened ; four anterior coxae and hind femora strongly darkened ; the four anterior trochanters and middle femora basally, commonly but not always darkened ; flagellum dark brown ; palpi and tibial spurs pale to white ; stigma, costal vein, and metacarp, reddish brown, remaining veins virtually colourless.

♀♂. *Head*: face punctate (degree 3); vertex finely punctate; occiput indefinitely rugoso-punctate. *Thorax*: mesonotum with well-separated punctures (degree 3–4) that are more or less evenly spaced throughout and as a rule not more widely spaced than one diameter; disc of scutellum minutely punctate (degree 1), polished and shining; propodeon with the areola and costulae strongly marked, otherwise more or less unsculptured, smooth, and shining. *Wings*: the recurrent about equal to or rather shorter than the breadth of the stigma, shorter than the 1st abscissa of the radial, longer than the transverse cubital; the apical portion of the 1st abscissa of the cubital shorter than the transverse cubital, just longer than the pigmented portion of the 2nd abscissa of the cubital, this latter about equal to the upper portion of the basal vein; stigma shorter than metacarp. *Legs*: hind coxae on outer faces minutely punctate (degree 1), basally above definitely punctate (degree 2–3). *Abdomen*: 1st tergite more or less parallel-sided, in basal half rugose and medianly tumescent, in apical half medianly unsculptured and shining, laterally with punctures and striae; 2nd tergite apparently unsculptured; ovipositor sheaths longer than the hind tarsus.

Length, 2 mm.

JAVA: 7 ♀♀, 5 ♂♂, xii.1925 (*B. van der Goot*).

Type deposited in the British Museum.

Host: the Hesperiid, *Hasora mixta*, Mab., on *Derris*.

Cocoons unknown.

73. Apanteles fistulae, sp. n.

♀♂. Agrees in colour with my redescription of *A. stantoni*.

♀. Agrees in sculpture with my redescription of *A. stantoni* except as follows: *Wings*: the recurrent equal to the breadth of the stigma, shorter than the 1st abscissa of the radial, longer than the transverse cubital; the pigmented portion of the 2nd abscissa of the cubital rather shorter than the apical portion of the 1st abscissa of the cubital, about half as long as the recurrent, considerably longer than the upper portion of the basal vein; stigma shorter than metacarp. *Legs*: hind coxae basally above sparsely punctate (degree 2). *Abdomen*: ovipositor sheaths definitely longer than the hind tarsus.

♂. Agrees with my redescription of the sculpture of the ♂ of *A. stantoni*.

Length, 2–3 mm.

INDIA: Nilambur, Madras, 7 ♀♀, 7 ♂♂, 2.vii.1925 (*S. N. Chatterjee*).

Type deposited in the British Museum.

Host. Recorded as bred from a Pyralid defoliating *Cassia fistula*.

Cocoons unknown.

A species remarkably like *A. stantoni*, but certainly different; characters by which these species may be separated were also obtained in the arrangement of the sensoria of the flagellum.

74. Apanteles inquisitor, sp. n.

♀♂. Agrees in colour with my redescription of *A. stantoni* except that in the ♀ the hind femora are decidedly darkened at least basally and often wholly, while in the ♂ the middle femora in addition are darkened basally.

♀. Agrees well enough in sculpture with my redescription of *A. stantoni* except as follows: *Wings*: breadth of stigma less than the length of the 1st abscissa of the radial rather greater than the length of the recurrent; the transverse cubital variable in length but commonly equal to the apical portion of the 1st abscissa of the cubital,

and barely longer than half the 1st abscissa of the radial, more than twice as long as the pigmented portion of the 2nd abscissa of the cubital, this latter equalling the upper portion of the basal vein ; stigma shorter than metacarp. *Abdomen* : ovipositor sheaths definitely longer than hind tarsus.

♂. Agrees with my redescription of the sculpture of the ♂ of *A. stantoni*.

Length, 2–2·5 mm

MALAYA : Kuala Lumpur, 8 ♀♀, 1 ♂, 27.v.1925 (*G. H. Corbett* —type), and 7 ♀♀, 2 ♂♂, 21.ii.1925 (*G. H. Corbett*).

Type deposited in the British Museum.

Host : the Pyralid, *Lamprosema diemenalis*, Guér.

Cocoons white, solitary.

Apart from the venational characters, this species, from the descriptions, differs from *A. fistulae* only in the colour of the hind femora ; critical examination of the arrangement of the sensoria of the flagellum, however, reveals differences sufficiently regular and well-marked to justify the separation of these species on this variable colour character.

Species unknown to the writer or otherwise of doubtful position.

Apanteles angustibasis, Gah.

Apanteles angustibasis, Gahan, Phil. Jl. Sci., xxvii, 1925, p. 85.

A species described from a single female specimen.

Type in the U.S. National Museum.

The type locality is given as Luzon, Mount Maquiling, Philippine Islands.

Host : the Pyralid, *Cnaphalocrocis medinalis*, Guenée.

Cocoons unknown.

I have not seen this species ; it is, apparently, distinctive on account of the shape of the 1st tergite, which is parallel-sided, narrow, and "three or more" times as long as broad.

Apanteles aucklandensis, Cam.

Apanteles aucklandensis, Cameron, The Subantarctic Is. of New Zealand, i, 1909, p. 77.

A species described from a single male only.

Type, which is in very bad condition, lacking the abdomen, is in the British Museum.

The type locality is Carnley Harbour, Auckland Island.

Host unknown.

Cocoons unknown.

Apanteles fakhrulhajiae, Mahdn.

Apanteles fakhrulhajiae, Mahdihassan, J. Sci. Association, Vizianagaram, ii, 1925, p. 81.

I cannot recognise this species from the description, which is as follows :—"General appearance and size same as *A. tachardiae*, legs and undersurface of abdomen yellow instead of black, stigma brownish instead of being translucent as in *A. tachardiae*. The colour of abdomen shows great colour variation ; sides may be three-fourths yellow sometimes almost the whole of dorsal surface of the same colour. Such

specimens were reared only from Sohagpur Nagoli lac material. In Mysore lac the dorsal surface of abdomen is invariably black, sometimes the sides also. It has not been found except in Nagoli and Mysore lac."

Type. It is possible that no specimens have been preserved, and consequently that there is no type. Letters to the Editors of the Journal failed to elicit any reply.

Host: the Blastobasid moth *Holcocera pulverea*, Meyr., which feeds on *Tachardia* in company with the Noctuid moth *Eublemma amabilis*, Moore.

Cocoons unknown.

Apanteles lucidinervis, nom. n.

Urogaster albinervis, Ashmead, Proc. U.S. Nat. Mus., xxix, no. 1416, 1905 (1906), p. 118 (*nec* Cameron, 1904).

A species described from the male only.

Type in the United States National Museum.

The type locality is Manila.

Host unknown.

Cocoons unknown.

Apanteles nonagriae, Olliff.

Apanteles nonagriae, Olliff, Agric. Gaz. N.S. Wales, iv, 1893, p. 381.

A species described from males and females.

Type: location unknown.

The type locality is given as Richmond and Clarence River districts, New South Wales.

Hosts. Recorded by Olliff as parasitic on larvae of the Noctuid sugar-cane borer, *Nonagria exitiosa*, Olliff, and by Jarvis (Queensland Agric. Journ., xvi, 1921, p. 387) as parasitising larvae of the Noctuid, *Phragmatiphila truncata*, Walk., under which latter species and genus *Nonagria exitiosa* is now synonymised.

Cocoons. These are undescribed, but it is recorded by Olliff that they are generally attached to the dead remains of the larva within the burrow.

This species is undoubtedly closely related to *A. flavipes*, Cam., and in fact may actually be synonymous with it.

Apanteles novoguineensis, Szép.

Apanteles novoguineensis, Szépligeti, Ann. Mus. Nat. Hung., iii, 1905, p. 50.

♀. Black; the forelegs distally from apex of femora, basal half of middle tibiae, middle tarsi, and basal quarter of hind tibiae, red testaceous; palpi and tibial spurs pale; costal veins more or less testaceous; stigma and wing veins brown.

♀. *Thorax*: mesonotum with well marked but not very well-separated punctures (degree 3–4), reticulately or rugosely punctate along the lines of the notauli; disc of scutellum impunctate, smooth, polished, shining; propodeon with the carinae of the areola and costulae very strong; the areola obtusely V-shaped at apex and definitely closed at base by a carina weaker than the other carinae of the areola; the areola is smooth and shining, as is most of the propodeon. *Wings*: the breadth of the stigma definitely less than the length of the 1st abscissa of the radial, just greater than the length of the recurrent, which latter is very definitely longer than the transverse cubital; the apical portion of the 1st abscissa of the cubital equal to the transverse cubital, nearly twice as long as the pigmented portion of the 2nd abscissa

of the cubital, which latter is possibly just longer than the upper portion of the basal vein ; stigma shorter than metacarp. *Legs* : hind coxae above basally and above towards apex closely finely rugose, on outer faces largely impunctate and shining ; the longer hind tibial spur rather more than half, and the shorter spur rather less than a third, the length of the basal joint of the hind tarsus. *Abdomen* : 1st tergite possibly about 1·5 times as long as broad at apex, somewhat broader towards middle than either at base or apex, medianly strongly tumescent, in apical half finely rugose and rugosely striate ; 2nd tergite as broad at base as the apical breadth of the 1st tergite, at apex just a little broader than 1·5 times the basal breadth, with median length about one-fifth apical breadth, virtually entirely smooth, with the short lateral sulci well-marked and nearly straight, the apical suture extremely fine ; 3rd tergite at least twice as long as the 2nd ; ovipositor sheaths missing.

Length, 3·25 mm.

Redescribed from the type, which was kindly lent me by Dr. Biró.

Type in the Hungarian National Museum, Buda-Pest.

The type locality is Simbang, New Guinea.

Host unknown.

Cocoons unknown.

A species originally described from a single damaged female.

Apanteles steganodactylae, Cam.

Apanteles steganodactylae, Cameron, Spol. Zeylan., vi, pt. 21, 1909, p. 42.

A species described from a single male only.

Type in the British Museum.

The type locality is Galle, Ceylon.

Host. Bred from the Pterophorid, *Steganodactyla*, now *Ochyrotica*, *concursa*, Wlsm.

Cocoons snow-white.

This species should possibly be synonymised under *A. subductus*, Walk.

Apanteles subductus, Walk.

Microgaster subductus, Walker, Ann. Mag. Nat. Hist., (3) v, 1860, p. 309.

Described from a single male only.

Type in the British Museum.

The type locality is Ceylon.

Host unknown.

Cocoons unknown.

The specimen is in bad condition. This species is probably the same as *A. steganodactylae*, Cam.

Key to the Species.

1. Propodeon without areola, with or without median longitudinal carina ; ovipositor short except in *belippae* ... ... 2.
   Propodeon with areola as a rule strongly, but often obscurely, marked, and occasionally with areola entirely wanting, in which case there may or may not be a median longitudinal carina ; 2nd tergite short, transverse ; ovipositor noticeably exserted ... ... 47.

2. First tergite no broader at apex than at base, usually narrower, in middle often rounded and broader than either at base or apex, or if not thus rounded and broader then the apex noticeably narrowed ; 2nd tergite perfectly smooth and shining, with a pair of distinctly impressed lines more or less discally converging towards base ... ... 3.
First tergite at apex as broad as or broader than at base, if as broad then with the sides more or less parallel throughout ; 2nd tergite almost invariably aciculate-punctate, rugose, roughened, or otherwise sculptured, and generally with curved impressed lines round the lateral margins ... ... 28.

3. Ovipositor sheaths about half length of abdomen ... ... 1. *belippae*, Rohw.
Ovipositor sheaths considerably shorter ... ... 4.

4. First tergite clear red testaceous throughout, without any traces of darkening 5.
First tergite at least with some portions nigrescent or black ... ... 7.

5. First tergite strongly and regularly constricted to apex as in *A. belippae* (fig. 1, *b*) or *A. creatonoti* (fig. 1, *h*) ... ... [*lautellus*, Marsh.]
First tergite not so describable ... ... 6.

6. Flagellum opaque red testaceous basally, nigrescent apically ; mesonotum very weakly punctate anteriorly ; 2nd tergite with lateral sulci widely divergent ... ... 2. *agamemnonis*, Wilkn.
Flagellum black to dark brown ; mesonotum more strongly punctate anteriorly ; 2nd tergite with lateral sulci not widely divergent 3. *papilionis*, Vier.

7. First tergite testaceous but nigrescent towards apex ... ... 8.
First tergite wholly black or very dark red black ... ... 9.

8. Hind coxae black ... ... 4. *obliquae*, Wilkn.
Hind coxae red testaceous ... ... 5. *creatonoti*, Vier.

9. Propodeon with well marked, median, longitudinal carina, and strong transverse basal carinae ... ... 6. *erionotae*, Wilkn.
Propodeon without strong median longitudinal, or transverse basal, carinae 10.

10. Hind femora shining red testaceous ... ... 11.
Hind femora black, nigrescent, or dark brown ; hind coxae on outer face above impunctate, smooth and dully shining, except in *nigrescens* ... ... 22.

11. All coxae red or pale red-yellow testaceous ... ... 12.
At least hind coxae black, or very strongly nigrescent, generally all coxae dark ... ... 13.

12. Propodeon shining, without carinae, if at all punctate then extremely finely (degree 1) ; 1st tergite apparently impunctate except possibly along lateral margins ... ... 7. *aristolochiae*, Wilkn.
Propodeon with numerous fine carinae, and punctate (degree 3) ; 1st tergite strongly punctate in apical half ... ... 8. *badgleyi*, Wilkn.

13. All coxae black or very dark ... ... 14.
Only hind coxae black, the four anterior coxae light red testaceous ... 19.

14. Median area of 2nd tergite very small and noticeably convex, at apex apparently not even as broad as apex of 1st tergite ... ... 9. *acheronliae*, Cam.
Median area of 2nd tergite at apex as broad as or just broader than extreme breadth of the 1st tergite ... ... 15.

15. Propodeon with median longitudinal excavation which is particularly noticeable towards the base ... ... 10. *ashmeadi*, Wilkn.
Propodeon without such excavation, evenly rounded ... ... 16.

16. Mesonotum obscurely or very finely punctate (degree 1) ; antennae completely dark ... ... 17.
Mesonotum highly shining, occasionally rather weakly, but distinctly, separately, punctate (degree 2–4) ; antennae in some part red testaceous ; apex of hind tibiae, and hind tarsi, decidedly nigrescent ... ... 18.

17. First abscissa of radial not strongly angled with, and about equal to, the transverse cubital ; hind coxae apparently not punctate basally above ; apex of hind tibiae, and hind tarsi, hardly if at all nigrescent 11. *colemani*, Vier.
First abscissa of radial strongly angled with, and decidedly longer than, the transverse cubital ; hind coxae punctate basally above (degree 4) ; apex of hind tibiae, and the hind tarsi, decidedly nigrescent [*caberae*, Marsh.]

18. Tegulae black or very dark ; hind coxae highly shining ; 1st abscissa of radial definitely not strongly angled with the transverse cubital 12. *bataviensis*, Rohw.
Tegulae testaceous ; hind coxae dully shining ; 1st abscissa of radial not angled with the transverse cubital ... ... 13. *lamprosemae*, Wilkn.
Tegulae testaceous ; hind coxae highly shining ; 1st abscissa of radial very definitely angled with the transverse cubital *obliquae* var. *niger*, Wilkn.

19. Stigma light red testaceous ... ... [*lautellus*, Marsh.]
Stigma brown ... ... 20.

20. Transverse cubital considerably longer than 1st abscissa of radial [*thompsoni*, Lyle.]
First abscissa of radial longer than transverse cubital ... ... 21.

21. Wings virtually hyaline ; impressed lines on the 2nd tergite straight throughout their length ; 1st, 2nd, and 3rd tergites narrowly margined with testaceous ; 3rd tergite almost completely black ... ... 14. *puera*, Wilkn.
Wings very slightly infumated ; impressed lines on 2nd tergite towards apex curved downwards and almost parallel ; 1st and 2nd tergites broadly margined with light red testaceous ; 3rd tergite almost entirely light red testaceous 15. *lamborni*, Wilkn.

22. Hind femora reddish brown ; middle femora entirely light testaceous or yellowish ... ... 23.
Hind femora deep red-brown to black ; middle femora at least nigrescent basally ... ... 25.

23. Hind coxae red, more or less unicolorous with hind femora ; middle femora yellowish ... ... 16. *philippinensis*, Ashm.
Hind coxae black ; middle femora red testaceous ... ... 24.

24. Second tergite with the lateral impressions straight 17. *phytometrae*, Wilkn.
Second tergite with the lateral impressions slightly curved 18. *corbetti*, Wilkn.

25. First abscissa of radial and transverse cubital slender and evenly rounded, about equal in length ... ... 26.
First abscissa of radial and transverse cubital thick and not evenly rounded, the latter longer than the former ... ... 19. *nigrescens*, Cam.

26. Mesonotum extremely finely punctate ; 1st tergite virtually unsculptured, shining and highly polished ... ... [*beneficus*, Vier.]
Mesonotum with the punctures if somewhat shallow yet strong and separated ; 1st tergite strongly punctate at least along margins ... ... 27.

27. Second tergite with the lateral sulci straight ... 20. *artonae*, Rohw.
Second tergite with the lateral sulci slightly curved 21. *taylori*, Wilkn.

28. Thorax compressed dorso-ventrally, wider between the tegulae than thick dorso-ventrally; head viewed from side unusually prominent below antennae 29.
Thorax not compressed dorso-ventrally; head not unusually prominent below antennae ... ... 30.

29. Hind coxae red testaceous; propodeon declivous behind; face prominent 22. *flavipes*, Cam.
Hind coxae black except at apex; propodeon nearly flat; face not especially prominent ... ... 23. *chilocida*, Vier.

30. Third tergite largely rugose, rugulose, or closely rugulosely striate, at least at base ... ... 31.
Third tergite smooth and shining, at least not rugulose ... ... 32.

31. All femora (except hind femora sometimes at extreme apices) entirely clear red testaceous; mesonotum in some part strongly and closely punctate 24. *ruidus*, Wilkn.
Femora always very largely darkened, sometimes all completely black; mesonotum in no part strongly and closely punctate [*salebrosus*, Marsh.]

32. Hind coxae closely rugose and dull ... ... 25. *antipoda*, Ashm.
Hind coxae shining, at most closely punctate ... ... 33.

33. Transverse cubital obviously longer and stouter than 1st abscissa of radial, with a stump at their point of junction ... ... 26. *philocampus*, Cam.
These veins not thus describable ... ... 34.

34. Head almost entirely with very strong, well separated, punctures 27. *pratapae*, Ashm.
Punctures on head not so describable ... ... 35.

35. Mesonotum without coarse or strong punctures, if at all punctate then the punctures very shallow and virtually coalescent ... ... 36.
Mesonotum at least in some part strongly, or coarsely, and separately punctate ... ... 37.

36. Propodeon with only a weak median longitudinal carina, and no transverse basal carinae; 2nd tergite with lateral sulci definitely more strongly impressed at base than at apex ... ... 28. *glomeratus*, L.
Propodeon with a strong median longitudinal carina, and strong transverse basal carinae; 2nd tergite with lateral sulci evenly impressed to apex of tergite ... ... 29. *paludicolae*, Cam.

37. Propodeon with distinct transverse basal carinae ... ... 39.
Propodeon without such carinae ... ... 38.

38. Scape dark red-black to black; extreme apices of hind femora and of hind tibiae definitely nigrescent ... ... 30. *australiensis*, Ashm.
Scape pale red testaceous; apices of hind femora and of hind tibiae apparently not nigrescent or but hardly so ... ... 31. *deliadis*, Bing.

39. Second tergite without lateral sulci ... ... 32. *taprobanae*, Cam.
Second tergite with lateral sulci ... ... 40.

40. Hind femora largely strongly darkened to black, at least apical third or quarter so darkened; wings very definitely infumated ... ... 41.
Hind femora if darkened at all only at extreme apex; wings hyaline or but very slightly infumated ... ... 42.

41. First tergite with median length about equal to greatest breadth [*rubecula*, Marsh.]
First tergite very definitely longer than broad 33. *cheesmanae*, Wilkn.

42. Tegulae darkish red to red-black ... ... 43.
Tegulae pale, colourless, or light yellowish, testaceous ... ... 46.

43. First abscissa of radial equal to or even sometimes shorter than transverse cubital ... ... 44.
First abscissa of radial very definitely longer than transverse cubital ... 45.

44. Second tergite indefinitely sculptured; 2nd suture as strong as the strong lateral bounding sulci of 2nd tergite ... ... 34. *anthelae*, Wilkn.
Second tergite longitudinally striate; 2nd suture and lateral sulci not strong [*limbatus*, Marsh.]

45. Metacarp longer than stigma; apical portion of 1st abscissa of cubital about equal to pigmented portion of 2nd abscissa of cubital; 3rd tergite yellowish 35. *tiracholae*, Ashm.
Metacarp not longer than stigma; apical portion of 1st abscissa of cubital longer than pigmented portion of 2nd abscissa; 3rd tergite deep black 36. *effrenus*, Wilkn.

46. Lateral sulci of 2nd tergite weak; hind ocelli noticeably further from each other than from eyes ... ... 37. *rufiventris*, Bing.
Lateral sulci of 2nd tergite strong; hind ocelli not so describable 38. *hypsipylae*, Wilkn.

47. Flagellum with a white band (♀)... ... ... 39. *taeniaticornis*, sp. n.
Flagellum normally coloured ... ... 48.

48. Propodeon with a strong median longitudinal carina ... ... 49.
Propodeon without median longitudinal carina, with areola or with strong indications of an areola ... ... 51.

49. Propodeon, and 1st and 2nd tergites, rugose; stigma dark brown 40. *recusans*, Walk.
Propodeon, and 1st and 2nd tergites, not rugose; stigma not dark brown 50.

50. Ovipositor sheaths definitely shorter than hind tarsus 41. *detrectans*, sp. n.
Ovipositor sheaths definitely longer than hind tarsus 42. *cajani*, sp. n.

51. Propodeon without costulae, often with the areola virtually absent or but weakly deliminated ... ... 52.
Propodeon with costulae which are commonly very strongly marked; areola invariably strongly marked... ... ... 70.

52. Hind femora entirely clear red testaceous throughout ... ... 53.
Hind femora black, dark red, or at least black above and below ... ... 54.

53. ♀ with 1st tergite as broad or broader at apex than at base 45. *hyblaeae*, sp. n.
♀ with 1st tergite definitely narrower at apex than at base 44. *calycinae*, sp. n.

54. Mesonotum closely rugose or rugoso-punctate, dull, and strongly setiferous; disc of scutellum largely (at least lateral thirds) closely but shallowly punctate, also noticeably setiferous ... ... 46. *singaporensis*, Szép.
Mesonotum neither closely rugose nor rugoso-punctate, and not dull, but shining and generally with the punctures separate, or if not separate then extremely shallowly punctate; disc of scutellum largely unsculptured 55.

55. Ovipositor sheaths definitely longer than hind tibia ... ... 56.
Ovipositor sheaths rather shorter than hind tibia ... ... 66.

56. Areola obviously closed at base by a straight, transverse carina as strong as or stronger than its lateral carinae ... ... 57.
Areola even if present not thus closed ... ... 59.

57. The smooth shining area on lateral faces of scutellum very small, hardly as long as breadth of scutellum at apex; disc of scutellum not entirely smooth; 1st tergite more or less longitudinally striate ... ... 48. *phycodis*, Vier.
The smooth shining area obviously much longer than breadth of scutellum at apex; disc of scutellum almost entirely smooth; 1st tergite rugose 58.

58. Ovipositor sheaths shorter than hind tarsus ... ... 49. *leptoura*, Cam.
Ovipositor sheaths longer than hind tarsus ... ... 50. *araeceri*, sp. n.

59. Propodeon in apical half with well marked areola, in basal half with a single well marked median longitudinal carina ... 50. *araeceri*, sp. n.
Propodeon not thus describable ... ... 60.

60. Stigma hyaline, margined with brown or with red testaceous ... ... 61.
Stigma opaque ... ... 64.

61. Areola well marked throughout length of propodeon ... ... 62.
Aerola marked only at apex of propodeon ... ... 63.

62. Stigma margined with red testaceous; hind tibiae somewhat darkened in apical half; 1st tergite in apical half rugose ... ... 51. *tachardiae*, Cam.
Stigma margined with brown; hind tibiae black for at least apical two-thirds; 1st tergite not rugose in apical half ... ... 52. *importunus*, sp. n.

63. Propodeon medianly roundly excavate; 1st abscissa of radial longer than the transverse cubital ... ... 47. *leptothecus*, Cam.
Propodeon medianly strongly convex; 1st abscissa of radial not longer than transverse cubital ... ... [*halidaii*, Marsh.]

64. ♀ with 1st tergite definitely and strongly narrowed at apex 44. *calycinae*, sp. n.
♀ with apex of 1st tergite as broad as or broader than the base, at least not definitely and strongly narrowed ... ... 65.

65. ♀ with 1st tergite strongly rugoso-punctate (or punctato-reticulate) 53. *tasmanica*, Cam.
♀ with 1st tergite smooth, polished, and shining, with widely separated, strong punctures ... ... 54. *birói*, Szép.
♀ with 1st tergite finely punctate ... ... [*sicarius*, Marsh.]

66. Areola marked only at apex ... ... 67.
Areola strongly marked, at least in apical half ... ... 68.

67. Stigma hyaline bordered with red testaceous 47. *leptothecus*, Cam.
Stigma black ... ... [*sicarius*, Marsh.]

68. Ovipositor sheaths only as long as the basal joint of the hind tarsus 43. *javensis*, Rohw.
Ovipositor sheaths nearly as long as the hind tibia ... ... 69.

69. Hind ocelli nearer to each other than to eyes ... 55. *bisulcata*, Cam.
Hind ocelli nearer to eyes than to each other ... 56. *machaeralis*, sp. n.

70. Disc of scutellum strongly rugoso-punctate, as strongly as the mesonotum 57. *significans*, Walk.
Disc of scutellum not rugoso-punctate, at least not so strongly as the mesonotum ... ... 71.

71. Sheaths of ovipositor not longer than basal joint of hind tarsus ... ... 72.
Sheaths of ovipositor longer than basal joint of hind tarsus ... ... 76.

72. Disc of scutellum with separated, more or less strong punctation; 1st tergite with a noticeable median longitudinal carina; 2nd tergite strongly rugose, 3rd generally rugose ... ... 58. *hemitheae*, sp. n.
Disc of scutellum impunctate or with but a few weak punctures; 1st tergite without or with but a hardly noticeable median longitudinal carina; 2nd tergite generally rugose or striate, 3rd never ... ... 73.

73. Second tergite definitely with transverse striae at middle at apex 62. *caniae*, sp. n.
Second tergite without such striae ... ... 74.

74. Scape and hind femora invariably completely nigrescent to black; 2nd tergite but faintly sculptured, at least three times as broad at apex as long down middle ... ... 59. *hyposidrae*, sp. n.
Scape and hind femora never completely nigrescent; 2nd tergite strongly sculptured, never as much as three times as broad as long ... ... 75.

75. First abscissa of radial and transverse cubital evenly rounded; hind femora clear, bright, red testaceous throughout ... ... 60. *expulsus*, Turn.
First abscissa of radial slightly but definitely angled with the transverse cubital; hind femora commonly more or less nigrescent ... 61. *mendañae*, sp. n.

76. Ovipositor sheaths as short as or shorter than hind femora ... ... 77.
Ovipositor sheaths longer than hind femora... ... ... 82.

77. Hind femora light red testaceous or red testaceous, never darker than basal half of hind tibiae ... ... 78.
Hind femora red brown, brown, or nigrescent, always darker than basal half of hind tibiae ... ... 80.

78. First tergite in middle third finely rugose, in apical third finely striate, with a few fairly strong but not very evident punctures; 2nd tergite definitely with fine transverse striae at middle at apex ... ... 62. *caniae*, sp. n.
First tergite not so describable; 2nd tergite unsculptured or with longitudinal striae ... ... 79.

79. Second tergite definitely longitudinally striate ... 63. *heterusiae*, sp n.
Second tergite unsculptured ... ... 64. *prodeniae*, Vier.

80. Areola at apex v-shaped; divisions of propodeon with numerous, strong, irregular, secondary carinae ... ... 65. *opacus*, Ashm.
Areola at apex not acutely angled, but rounded or square; divisions of propodeon not so describable ... ... 81.

81. Propodeon with carinae of areola and of costulae unusually strong; 1st tergite in the ♀ in apical quarter virtually smooth ... 66. *parasae*, Rohw.
Propodeon with carinae of areola and of costulae if anything rather weaker than is normal for this group; 1st tergite of ♀ in apical quarter definitely striate ... ... 67. *bambusae*, sp. n.

82. Ovipositor sheaths shorter than hind tibiae, often only barely longer than hind femora ... ... 83.
Ovipositor sheaths as long as or longer than hind tibiae ... ... 86.

83. Areola at apex v-shaped ... ... 65. *opacus*, Ashm.
Areola at apex rounded or squared ... ... 84.

84. Hind femora red testaceous; 2nd tergite striate ... 63. *heterusiae*, sp. n.
Hind femora darkened; 2nd tergite unsculptured ... ... 85.

85. First tergite comparatively smooth, at most with some noticeable but more or less badly deliminated and irregular punctation and sculpture, not in any part even approaching rugose ... ... 68. *agilis*, Ashm.
First tergite medianly dull with a rugose tumescence, apically shining and smooth ... ... 66. *parasae*, Rohw.

86. Ovipositor sheaths shorter than hind tarsus ... ... 87.
Ovipositor sheaths as long as or longer than hind tarsus ... ... 88.

87. Hind femora completely darkened ... ... 68. *agilis*, Ashm.
Hind femora completely red to yellow-red testaceous ... 69. *stantoni*, Ashm.

88. Mesonotum in part rugose, or rugosely striate, noticeably so along the lines of notauli posteriorly ... ... 70. *taragamae*, Vier.
Mesonotum not so describable, punctures strong and definitely separate although sometimes closely placed ... ... 89.

89. Scape invariably completely darkened to black; hind femora completely darkened or usually at least darkened above and below somewhat ... 90.
Scape invariably largely bright red testaceous; hind femora completely bright red testaceous except in *A. inquisitor* ... ... 92.

90. Stigma brown, with a white cloud occupying the basal fourth, or even largely hyaline with the borders pigmented ... ... [*diparopsidis*, Lyle]
Stigma uniformly darkened throughout ... ... 91.

91. Punctures on mesonotum widely separated (commonly by two diameters); disc of scutellum, hind coxae basally above, impunctate, highly polished; the smooth shining area on lateral faces of scutellum small, hardly as long as breadth of disc of scutellum at apex ... ... 71. *platyedrae*, sp. n.
Punctures on mesonotum as a rule not separated by more than one diameter; disc of scutellum minutely, hind coxae basally above definitely, punctate; the smooth shining area on lateral faces of scutellum large, longer than breadth of disc of scutellum at apex... ... ... 72. *hasorae*, sp. n.

92. Ovipositor sheaths about equal to hind tarsus ... 69. *stantoni*, Ashm.
Ovipositor sheaths definitely longer than hind tarsus ... ... 93.

93. Hind femora clear, bright, red testaceous throughout 73. *fistulae*, sp. n.
Hind femora somewhat darkened at least basally ... 74. *inquisitor*, sp. n.

Host List.

Acherontia lachesis, F.	*A. acherontiae*, Cam.
Acherontia styx, Westw.	*A. acherontiae*, Cam.
Agrotis sp.	*A. antipoda*, Ashm.
Anthela ocellata, Walk.	*A. anthelae*, Wilkn.
Anticarsia irrorata, F.	*A. expulsus*, Turn.
Araecerus fasciculatus, DeG.	*A. araeceri*, sp. n.
Argyroploce codonectis, Meyr.	*A. stantoni*, Ashm.
Artona albicilia, Hamps.	*A. taylori*, Wilkn.
Artona catoxantha, Hmps.	*A. artonae*, Roh.
Belippa see *Nemeta*.	
Cania bilinea, Walk.	*A. caniae*, sp. n.
Chilo simplex, Butl.	*A. chilocida*, Vier.; *A. flavipes*, Cam.
Cnaphalocrocis medinalis, Guen.	*A. angustibasis*, Gah.
Cosmopteryx bambusae, Meyr.	*A. bambusae*, sp. n.
Creatonotus albistriga, Walk.	*A. creatonoti*, Vier.
Creatonotus transiens, Walk.	*A. creatonoti*, Vier.
Darala see *Anthela*.	
Decadarchis heterogramma, Meyr.	*A. platyedrae*, sp. n.
Delias argenthona, F.	*A. deliadis*, Bing.
Diacrisia obliqua confusa, Butl.	*A. obliquae*, Wilkn.
Erionota thrax, L.	*A. erionotae*, Wilkn.
Glyphodes see *Margaronia*.	
Hasora mixta, Mab.	*A. hasorae*, sp. n.
Hemithea costipunctata, Moore...	*A. hemitheae*, sp. n.
Heterusia cingala, Moore	*A. heterusiae*, sp. n.
Hidari irava, Moore	*A. agilis*, Ashm.

Holcocera pulverea, Meyr.	*A. fakhrulhajiae*, Mahdn.
Homona coffearia, Nietn.	*A. taragamae*, Vier.
Hyblaea puera, Cram.	*A. puera*, Wilkn. ; *A. hyblaeae*, sp. n.
Hyblaea sanguinea, Gaede	*A. hyblaeae*, sp. n.
Hyposidra sp.	*A. hyposidrae*, sp. n.
Hypsipyla robusta, Moore	*A. antipoda*, Ashm. ; *A. hypsipylae*, Wilkn.
Lamprosema diemenalis, Guér.*	*A. inquisitor*, sp. n.
Margaronia glauculalis, G.	*A. stantoni*, Ashm.
Margaronia laticostalis, G.	*A. stantoni*, Ashm.
Naranga diffusa, Walk.	*A. antipoda*, Ashm.
Nemeta lohor, Moore	*A. belippae*, Rohw.
Nephopteryx sp.	*A. importunus*, sp. n.
Nonagria see *Phragmatiphila* and *Sesamia*.	
Ochyrotica concursa, Wlsm.	*A. bisulcata*, Cam. ; *A. steganodactylae*, Cam.
Odonestis see *Paralebeda*.	
Ogyris zosine, Hew.	*A. rufiventris*, Bing.
Orgyia postica, Walk.	*A. colemani*, Vier.
Papilio agamemnon, L.	*A. agamemnonis*, Wilkn
Papilio aristolochiae, F.	*A. aristolochiae*, Wilkn.
Papilio demodocus, Esp.	*A. papilionis*, Vier.
Papilio demoleus, L.	*A. papilionis*, Vier.
Papilio polytes, L.	*A. papilionis*, Vier.
Papilio sarpedon, L.	*A. papilionis*, Vier.
Paralebeda plagifera, Walk.	*A. bataviensis*, Rohw.
Parasa sp.	*A. parasae*, Rohw.
Parnara conjuncta, H.-S.	*A. javensis*, Rohw.
Perigea capensis, Guen.	*A. antipoda*, Ashm.
Phragmatiphila truncata, Walk.	*A. nonagriae*, Olliff.
Phycodes radiata, Ochs.	*A. phycodis*, Vier.
Phytometra chalcites, Esp.	*A. phytometrae*, Wilkn.
Phytometra peponis, F.	*A. taragamae*, Vier.
Phytometra signata,	*A. phytometrae*, Wilkn.
Pieris brassicae, L.	*A. glomeratus*, L.
Platyedra gossypiella, Saund.	*A. platyedrae*, sp. n.
Platyptilia molopias, Meyr.	*A. paludicolae*, Cam.
Plusia agramma, Guen.	*A. taragamae*, Vier.
Plusia see *Phytometra*.	
Pratapa deva, Moore	*A. pratapae*, Ashm.
Prodenia litura, F.	*A. prodeniae*, Vier.
Pyrausta machaeralis, Walk.	*A. machaeralis*, sp. n. ; *A. ruidus*, Wilkn.
Sesamia inferens, Walk.	*A. flavipes*, Cam.
Spodoptera mauritia, Boisd.	*A. antipoda*, Ashm.
Stauropus alternus, Walk.	*A. taprobanae*, Cam.
Steganodactyla see *Ochyrotica*.	
Tachardia sp.	*A. tachardiae*, Cam.
Taragama dorsalis, Moore	*A. taragamae*, Vier.
Tirachola plagiata, Walk.	*A. tiracholae*, Ashm.
Trichoptilus paludum, Zell.	*A. paludicolae*, Cam.

* Through a clerical error *Apanteles lamprosemae* was recorded in Part I of this paper as parasitising *Lamprosema diemenalis*, whereas in reality it was bred from a Lymantriid larva found on *Aleuritis montana*.

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HIEROXESTIS SUBCERVINELLA, WLK., AN ENEMY OF THE BANANA IN THE CANARY ISLANDS.

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(Plates IV and V.)

1. Introductory.

As the result of an invitation received during the earlier part of 1924, Dr. R. Stewart MacDougall, of the University of Edinburgh, kindly asked the writer to accompany him as assistant in order to pursue the investigation of an insect pest which was causing an appreciable amount of damage to the bananas of the Canary Islands. From a certain amount of information received from growers in the islands, and from other considerations, it was decided to proceed south in the early autumn. As a result, the months of September and October were devoted to field work in the islands, when it was possible to make observations on the attack of the pest and the damage done, and to collect material for further detailed work. The greater part of the laboratory study has been carried out in the Department of Entomology, the University of Edinburgh, and completed at the Institute of Agricultural Parasitology.

Of those insects which occurred as enemies of the Canary bananas the one under consideration was important. Reports from British and Spanish cultivators showed that the caterpillars of this moth had been observed at work at least in 1922, if not before, on banana, but that with the passage of time the damage had become much more evident and widespread. As a result of this the cultivators, with a certain apprehension for their crops, sought advice with regard to this problem.

Of the seven islands forming the archipelago, Teneriffe, Gran Canaria and Gomera were all visited as being the principal banana-producing islands. Many widely separated plantations were visited in each island, thus forming an extensive field for the work. The breeding of the insect, both in the open and under control, was made possible by a prolonged stay at Arucas in the north of the island of Gran Canaria, the plantations surrounding this town being badly infested.

The genus *Hieroxestis* was first recorded and described by Meyrick in 1892. The type was *H. omoscopa*, Meyr., from Newcastle and Sydney, New South Wales, possibly an introduction. Twenty-nine years previous to this date, in 1863, Walker first described the species under consideration under the name of *Tinea subcervinella*, Wlk. Melliss, twelve years later, in 1875, in his book on the island of Saint Helena, gives notes on two moths, viz.: *Gelechia sanctae-helenae* and *G. ligniferella*, both of which were described by Walker and have been found to be examples of *H. subcervinella*. In the following year, 1876, Butler made reference to the moth in Rodriguez under the name of *Laverna plumipes*, Butl. In 1879 Wollaston described the moth, with additional notes, under the name of *Euplocamus sanctae-helenae*, which is synonymous with the two names mentioned by Melliss (1875). After the lapse of several years Lord Walsingham in 1907 mentions the moth under the generic name of *Opogona*, and additional notes dealing principally with the distribution of the insect are found in the later writings of various workers. Durrant (1925) says that his "acquaintance with this species dates so far back as February 1895, when the late Monsieur E. L. Ragonot submitted specimens for determination from Mauritius and the Seychelles."

2. Notes on the Genus Hieroxestis, Meyr.

The characters of the genus as originally described by Meyrick (1892) are as follows: "Head with dense erect tuft on crown, face smooth; ocelli small; tongue developed. Antennae five-sixths, in ♂ serrulate, with whorls of short cilia, basal

joint very long, dilated, concave beneath, in ♂ with projection of dense scales on upper edge. Labial palpi moderately long, curved, ascending, smooth-scaled, second joint with several long bristles towards apex, terminal joint half second, rather thick, obtuse. Maxillary palpi long, filiform, folded. Posterior tibiae clothed with very long hairs. Forewings with vein 1 simple, 5 closely approximated at base to 6, 7 and 8 out of 6, 7 to costa, 9 from point with 6, 10 absent, 11 from three-quarters of cell. Hindwings four-fifths, lanceolate, cilia one-and-a-half; vein 4 approximated at base to 7, 5 and 6 out of 7, 6 to hind margin."

In discussing the genus Meyrick states that " this curious genus stands so far isolated from other Australian forms, that, taking into consideration its mode of feeding, I have suspected it to be an introduction from another region; however, I know no evidence of its occurrence elsewhere. It is allied to the *Tinea* group, but has undergone very great modification."

In writing of the fauna of the Seychelles Meyrick (1911) considers the genus to be apodemic as it is represented in the islands by several Indian species and a few from Africa and Mauritius. He also adds that " in its normal form this genus closely approaches *Opogona* in structure, and is evidently the direct progenitor of that genus, differing from it only by the tuft or fringe of rough hairs which rises from the fillet and projects over it, leaving the face, fillet, and back of crown quite smooth. The neuration exhibits a deceptive tendency to partial obsolescence, several of the veins (especially 2–4 and 11 of the forewings and 6 of the hindwings) being liable to almost complete disappearance, though a very faint trace or impression is barely perceptible; stress cannot be laid on this, the extent of obsolescence varying individually and specifically."

3. Distribution of Hieroxestis subcervinella, Wlk.

The records of the distribution of the insect show that it is principally an insular form, yet it would appear to be apodemic in the islands in which it occurs. From the various writings on the moth the records of the habitat are as follow: Seychelles (four records), Mauritius (six records), Rodriguez (two records), St. Helena (three records), Madeiras (two records), and the Canary Islands. Durrant (1923) records the curious occurrence of an adult, taken at rest on the inside of a window of a house at Margate on 14.x.22, and suggests that it had possibly been introduced, via the Canaries, in bananas.

Fig. 1. *Hieroxestis subcervinella*, Wlk.; venation of fore and hind wings.

4. Description of the Adult.

The following is a description of the moth given by Walker (1863):—

" *Male:* Cinereous fawn colour. Body beneath, abdomen, and hind wings pale cinereous. Palpi smooth, rather longer than the breadth of the head; third joint

linear, rounded at tip, a little more than half the length of the second. Abdomen extending for more than half its length beyond the hind wings. Hind tibiae with a long fringe. Wings narrow, acute. Forewings slightly tinged with aeneous and chalybeous, minutely blackish-speckled ; a dark dot in the disc at three-fourths of the length ; exterior border extremely oblique. Hind wings pale cinereous, with aeneous reflections ; fringe very long. Length of body 6 lines ; of the wings 14 lines."

Wollaston (1879) in writing of the moth says : " This is certainly one of the commonest members of the group, and better defined perhaps by its pale dusted surface [i.e., dusted with minute blackish scales—J.N.O.], and its general absence of obscure blotches or markings, than by any positive character which is immediately conspicuous. The male, however (in examples which are fresh and unrubbed), has a distinct blackish spot towards the apex of its anterior wings." Elsewhere, one reads that " the female, however, does not retain this marking, and is on the whole less irrorated with minute black scales. . . Thorax in the female concolorous with the anterior wings, but in the male of a rather darker hue."

5. Habits of the Adult.

In the Canary Islands the insect was found, either as larvae or adults, in practically all plantations visited, and these ranged in altitude from almost sea-level to 800 feet or 1,000 feet, depending on the limit of banana cultivation. The adults were observed in the latter part of September and during October, but as the field work in the islands terminated towards the end of October, the full period of adult activity could not be definitely ascertained.

Meyrick (1911), in reporting the occurrence of the moth in the islands of Mahé, Silhouette and Félicité, in the Seychelles group, states that it is found at an altitude of 1,000 feet from September to December. Of the other fifteen species of the genus *Hieroxestis* occurring in this locality the majority are found at a similar altitude up to 1,500 feet, or in some cases, 2,000 feet, while February, and September and October, are the months in which they were generally observed. Wollaston (*loc. cit.*) in writing of the moth says it occurs in St. Helena in " intermediate and lofty altitudes ; in fact it is abundant throughout those regions which are more or less clothed with the arborescent Compositae."

During the daytime the moths were inactive, those kept in breeding cages either seeking shelter beneath pieces of banana or remaining motionless in dark corners. When disturbed they would fly a short distance or flutter around for a few moments and again settle down. In the plantations adults were disturbed from their places of shelter beneath the large bracts of the banana inflorescence or between the ' fingers,' especially in the distal region of the inflorescence which does not develop. As evening approached, they became more active and would fly from spot to spot or keep running about when disturbed. In order to find out if the moths showed any marked attraction to light, a light trap, which had been built from Williams' design (1923), was employed burning acetylene gas. The trap was in use on several occasions, covering a period from dusk (about 7.30 p.m.) till dawn (6.30 a.m.). Careful watch was kept while the trap was in operation, and it was found that the moths, while not attracted to the light to a very marked extent, did respond to the stimulus, and several examples were caught. The principal period of activity was from dusk till about midnight, after which hour their activity almost entirely ceased. In this respect Durrant (1925) also notes that the moth " comes to light;" while Swezey (1909) in writing of *Opogona apicalis*, later found by Swezey (1922) to be *Hieroxestis omoscopa*, Meyr., an allied species in sugar-cane in Hawaii, notes that " the moths came numerously to lights, when I staid over night once at Waimea."

When at rest the moth remains with the wings folded close to the body, the fore-wings completely covering the hind ones, and presenting a roof-shaped appearance.

The wings are somewhat bent down at the tips. The antennae, as a rule, are held extending forwards. The proportion of the sexes was found to be in the ratio of 5 males to 6 females.

Blotting-paper moistened with sugar solution was provided as food for captive adults, but feeding was never observed.

Pairing and oviposition were not observed either under control or in the plantations.

6. Description of the Egg.

Although oviposition was not observed, Dr. MacDougall gave the writer about twenty eggs which had been expelled from moths that were asphyxiated by carbon bisulphide. Before death the females had deposited the eggs on the inside of a glass collecting tube, and the following description is based on this material.

The egg-mass, irregular in shape and somewhat flattened, consists of several eggs, a few of them slightly overlapping. The eggs are somewhat oval and measure on the average 0·62 mm. by 0·50 mm. Mutual pressure among eggs in contact with one another produces slight variations in shape. They are pale cream in colour, although a few exhibited a slightly greenish tint, and under a high power of the microscope there are indications of faint reticulate sculpturing. No micropyle was visible. The eggs were found to be fastened together and to the glass of the tube by a mucilaginous substance which had imbedded in it several scales from the wings and wing fringes.

The eggs were preserved shortly after their deposition, so that no further observations on development were possible.

7. Description of the Larva.

The Early Larva.

During the course of the field work the writer was unfortunate in not encountering any first stage larvae, and moreover, since pairing and egg-laying of the adults were not observed, it was impossible to breed any larvae through the various stages. In consequence the number of instars during larval life was not ascertained. Although several very small early stage caterpillars were taken, none were first stage larvae, since their setal arrangement coincided with that described for the full-grown larva. Fracker (1915) in his " Classification of Lepidopterous Larvae " has found that the setal arrangement of the first instar differs from the following ones and that certain setae (sub-primary) present in older larvae are lacking from the first stage ones. Since all the caterpillars examined were similar in setal arrangement to the full-grown one, it has been concluded that no first stage larvae were present. Moreover, the smallest caterpillar examined gave measurements of length and breadth rather too large to be in keeping with those of a larva which had hatched from the egg.

The various larvae of differing sizes which were examined corresponded with the description given for the full-grown stage. As already mentioned, the setal arrangement was the same, while the general appearance in colour and markings, prothoracic shield and suranal plate, showed no marked differences. It was observed, however, that the number of crochets on the prolegs varied in the different sizes of caterpillars, and that the smaller the larvae the fewer the crochets. In all cases they were uniordinal. Though several counts were made on larvae of varying sizes no grouping of the numbers was practicable, the numbers ranging from 15 crochets in the smallest larva examined up to the full complement of 50–60 in the last stage larva.

The Full-grown Larva.

The full-grown larva measures from 21 to 26 mm. in length and is cylindrical in shape with a slight taper towards the hind end. It measures 2–3 mm. in diameter at

its middle. The head is shining, reddish brown in colour, and varies from 2·0 to 2·4 mm. in width. The general colour of the caterpillar is a dirty white or pale cream-yellow, often with a tinge of green due to plant food matter within the alimentary canal. Various darker patches, greyish brown in colour, are definitely situated on the body segments. The prothorax bears a shield which is brown in colour and shining, extending over almost the entire length of the segment. It is divided in the mid-line by a narrow streak of paler cuticle. Each half of the shield is somewhat triangular. The dorsal surface of the mesothorax, metathorax and abdominal segments 1–9 is somewhat darker than the ventral owing to the above-mentioned patches. The last abdominal segment, the tenth, bears a dorsal, shining brown, chitinised area, the suranal plate, the anterior margin of which is practically straight, the posterior margin being rounded, almost semicircular in outline. Spiracles occur on the prothorax and abdominal segments 1–8. They have dark margins and are broadly elliptical in shape. The prothoracic and eighth abdominal spiracles are larger than the others. In position they occur towards the anterior edge of each segment, except for those on the prothorax ; they are within the posterior half of that segment. The last pair of spiracles are slightly more dorsal in position than the preceding ones. Various setae surround the spiracles, and the distribution of these can be seen from the setal maps (fig. 12). The larva is clothed with stiff hairs, light yellowish brown in colour, the arrangement and distribution of which are discussed below.

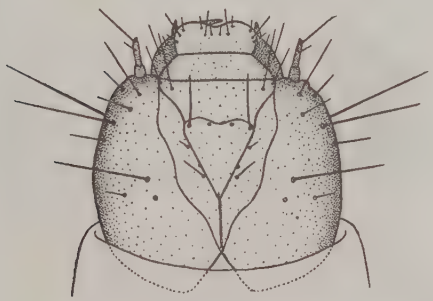

Fig. 2. Head of full-grown larva ; dorsal aspect.

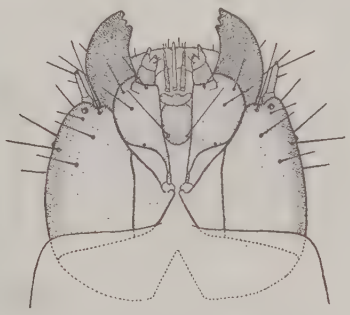

Fig. 3. Head of full-grown larva ; ventral aspect.

The *head*, viewed from above, is more or less circular in outline and a little broader than long (figs. 2, 3). It reaches its greatest width at the middle, but is slightly narrower and smaller than the prothoracic shield, and thus it can be partly withdrawn beneath the shield. In the normal position the latter extends slightly over the occipital region of the head-capsule. In conformity with the general characters of Lepidopterous larvae that are tissue-feeders and not sap-feeders, the dorsal side of the head is a little longer than the ventral one, but at the same time the hind margins are nearly on the same level, since the head is bent obliquely downwards. The head is not greatly depressed, however, and does not assume the thin wedge-shape of sap-feeders. There is a triangular incision of the dorsal hind margin of the capsule. The adfrontal sclerites are oblique and linear and stretch over the whole length of the head. The adfrontal suture is more or less sinuous, reaching the incision of the hind margin. The adfrontal ridges of the frons converge backwards towards the middle of the head, meeting at the apex of the frons to be continued as a longitudinal ridge which is almost one-third the length of the entire front.

Modification of the arrangement and number of the *ocelli* have occurred. One large ocellus with a convex lens is placed immediately posterior to the antenna on

the ventral surface. A second ocellus, somewhat smaller, is situated marginally and some little distance to the rear of the first one. The ocelli are apparently reduced and modified owing to the mining habits of the larvae and thus differ from those of the surface-feeding forms, which usually possess the full complement of eyes.

The *antennae* (fig. 4) are 3-segmented. The basal membrane consists of soft chitin and is fairly large and conspicuous. The basal segment is short and a little longer than broad. The middle segment is the largest, being long and narrow and brown in colour, as is the basal segment. It carries two bristles one of which is stout and very long, being about one and a half times the length of the entire antenna. It arises at the distal end of the segment and is slightly ventral in position. The other bristle is quite short, having origin about one-third of the length of the segment from the distal end. It also is slightly ventral in position. A circular pore is found a little past the middle of the segment in its proximal half. On the pale apex of the second segment several structures arise. There is the third small antennal segment which bears on its apex three structures, viz., a long bluntly conical striated appendage ; a very short similar appendage ; and a more pointed seta-like process.

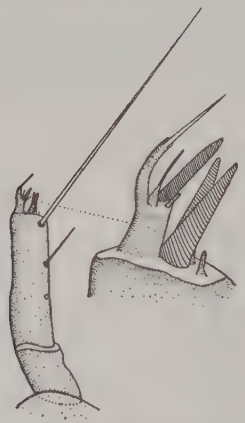

Fig. 4. Antenna of full-grown larva.

The inner lateral margin of the third segment is prolonged into a curved arm which terminates in a short seta. Further, on the apex of the second segment arise two comparatively long blunt conical processes, which are striated, and a very small peg-like papilla. It would appear that this comparatively long antenna with its very conspicuous bristle on the second segment might become damaged during the mining operations of the larva, but it has been observed that almost the whole organ is capable of being withdrawn within the basal membrane so that the forward edges of the epicranial plates afford it protection.

The *clypeus*, which has the labrum hinged to its anterior edge, takes the form of a broadly transverse plate.

The *labrum* (fig. 5) takes the form of a transverse plate, twice as long as it is broad. A very small median incision of the anterior edge divides it into two rounded lobes. This incised portion is more strongly chitinised than the remainder of the labrum. Dorsally, bristles of varying length occur on each side of the mid-line, forming six distinct pairs. Near the edge of each lobe are three lateral bristles, a short anterior, a longer median, and a posterior one of intermediate length. In the middle of each lobe occur two other median bristles, the one behind the other, situated on either side of the mid-transverse line. The posterior bristle is twice the length of the anterior

one. On either side of the mid-line of the labrum and situated midway between anterior and posterior edges is the third pair of median bristles. They are closely approximated. All these bristles have the appearance of being deeply imbedded in the labrum and not arising from surface pits. They are directed forwards and slightly upwards. Ventrally, the labrum carries no bristles but has six thorn-like chitinous projections, three on each lobe, towards its antero-lateral margin. The anterior one

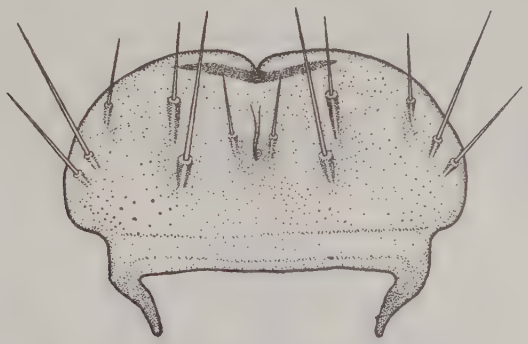

Fig. 5. Labrum of full-grown larva ; dorsal aspect.

is the longest and stoutest ; immediately behind it is a smaller one ; while the third, which is the smallest, occurs more towards the lateral margin of the labrum and is slightly posterior to the second projection. The posterior two-thirds of the labrum is clothed on the ventral side by the epipharyngeal membrane, which bears numerous very minute cuticular spines, directed backwards, and arranged in transverse rows. The anterior part of the labrum is visible from the ventral aspect of the head-capsule.

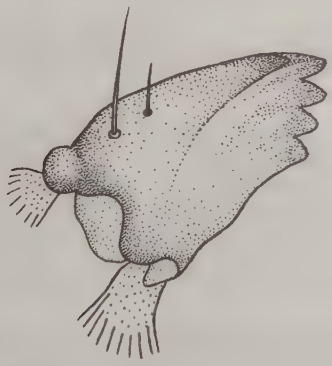

Fig. 6. Right mandible of full-grown larva ; ventral aspect.

The *mandibles* (fig. 6) are comparatively large, highly chitinised, and somewhat quadrilateral in shape, with convex exterior and concave interior surfaces. They are placed between the vertical and horizontal and meet in the mid-line when closed, the teeth interlocking. While the axes of rotation of the mandibles are not parallel but converge slightly dorsally, their toothed edges are not parallel with the axes, thus allowing the teeth to meet. The anterior edge of each mandible bears 5 teeth.

The ventral tooth is small and placed on level with and below the one next to it, which is the largest. The other three teeth are somewhat rounded at the tip and diminish successively towards the dorsal edge, thus bringing their tips into a line with one another. The four dorsal teeth therefore lie in a horizontal plane. A round articulating knob is found ventrally on the posterior margin of the mandible, and one long and one short seta occur near the outer edge on the ventral surface.

The *maxillae* (figs. 7, 8) lie one on each side of the labium. Each consists of a small cardo and a large stipes, which bears two setae. The stipes bears a palpiger, which in turn carries a 3-segmented maxillary palp, the terminal segment of which bears 4–5 minute processes. The first segment of the palp is comparatively large, as broad as long, with a single seta arising ventrally near the anterior margin and close beside a minute pit. It bears the second segment on the outer part of its pale apex, this second cylindrical segment also with a minute mid-ventral pit, in turn bearing the third small conical segment. Arising from the inner part of the apex

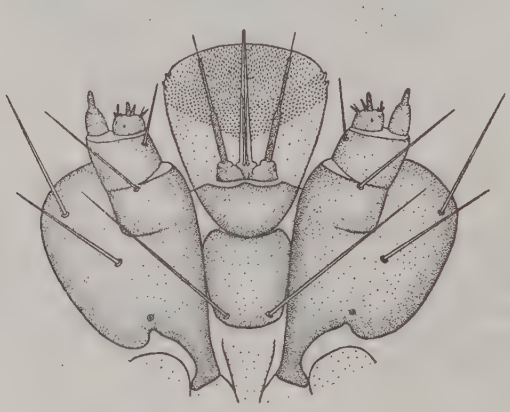

Fig. 7. Labium, maxillae and hypopharynx of full-grown larva; ventral aspect. The hypopharynx turned forward to show the dorsal aspect.

of the proximal segment of the palp is the maxillary lobe (which apparently corresponds to the fused galea and lacinia). This structure is cylindrical and broad and carries several chitinous projections of varying shape and size, viz., a central cone-like projection bearing at its tip a minute papilla ; a similar, but much smaller outer projection ; three stout pointed conical bristles with striae arising from near the dorsal edge of the pale apex of the maxillary lobe ; on the inner edge a single ordinary seta ; and finally two minute peg-like processes on the ventral part of the apex of the lobe.

The *hypopharynx* (fig. 7) consists of soft chitin and is tongue-like in shape. It is excavated in the middle dorsal region, the sides being in the shape of well-defined ridges, which bear several dense rows of minute spines. It occurs as a median pad on the oral surface of the labium. The posterior broad excavated region of the hypopharynx also is densely clothed with minute spines, directed backwards.

The *labium* (figs. 7, 9) lies between the maxillae and consists of the submentum, which is more or less quadrilateral and bears two long setae on its posterior margin ; the mentum, somewhat semicircular in shape with a transverse but undulating anterior border ; and the small transverse prementum which carries, distally, a median process, the spinneret, at the tip of which the silk glands terminate. On each side of the

spinneret occurs a labial palp. Each palp is long and thin, almost seta-like, and 2-segmented, the distal segment terminating in a fine hair. The spinneret is long and bristle-like and stretches as far forward as the anterior edge of the labrum.

Thoracic Legs. From the posterior aspect of the thoracic legs (fig. 10) the arrangement of the setae is as follows :—

The *coxa*, the largest segment, bears a chitinous plate on its inner surface at the distal margin of which two bristles arise, a very short one in the middle of the surface and a slightly longer one at the inner edge. Three comparatively long bristles arise in a transverse line about the middle of the coxa, on that part of the segment which bears no plate.

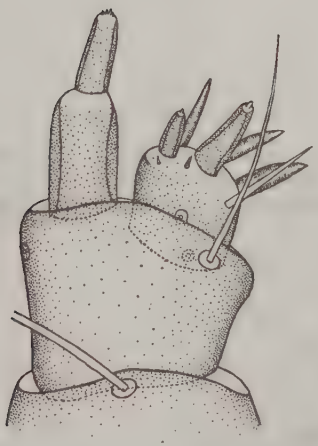

Fig. 8. Apex of maxilla of full-grown larva ; enlarged view, ventral aspect.

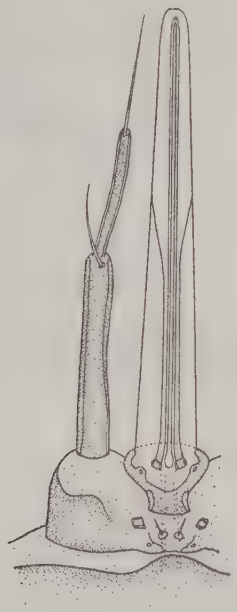

Fig. 9. Apex of labium of full-grown larva ; enlarged view, ventral aspect.

The *trochanter* is a very small segment consisting principally of thin chitin and appearing as a wedge between the coxa and femur. It bears no bristles.

The *femur* is somewhat cylindrical and longer than broad and carries two bristles ; one arises towards the inner margin, and the other occurs in the middle of the distal half of the segment. A triangular area more feebly chitinised than the rest of the femur is situated at the inner distal part of the segment.

The *tibia* is also somewhat cylindrical, longer than broad, and has six bristles arising in its distal half, forming a transverse line mainly on the posterior surface. A pit occurs on the outer margin at the mid-length of the tibia.

The *tarsus* is darker in colour than the preceding segments. It is bluntly conical and terminates in a claw, comparatively long and stout and slightly curved. At its base the claw shows a rounded knob on which two small papillae occur. In addition,

the tarsus bears a bristle on its outer margin near its distal end, and a second minute bristle arises a little above that already mentioned in the middle of the posterior surface.

The anterior surface of the leg is devoid of bristles with the exception of the tibia, which has two in its distal half on either side of the mid-line of the segment.

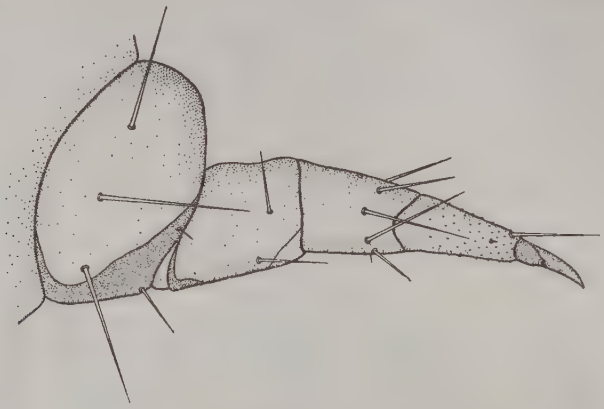

Fig. 10. Thoracic leg of full-grown larva; posterior surface.

Prolegs.—A pair of ventral prolegs (fig. 11) occurs on abdominal segments 3–6, and segment 10 bears a pair of anal prolegs. The planta of each proleg is slightly rounded, and in the case of segments 3–6, is crowned by a complete uniserial circle of

Fig. 11. Proleg of full-grown larva; ventral aspect.

uniordinal crochets which number between 50 and 60 to each leg. The anal prolegs, however, have the crochets extending only a little more than half round the planta and do not possess the complete circle. The bent apex, which forms the hook of the chitinous crochet, is directed towards the outside of the circle; surrounding the base

of the circlet of hooks, but situated on the proleg itself, is a narrow band which consists of numerous small papillae, each of which carries a very short stiff hair.

Dorsal to the proleg is a crescent shaped area which is slightly pigmented but devoid of spines. It bears three setae. In the same fashion, a single seta arises from a ventral area which continues to the mid-ventral line where it coalesces with the similar area of the other side.

The base of the proleg and the setae-bearing areas are free from the minute spines which cover the rest of the cuticle of the larva.

Arrangement of Setae and Body Markings.—The setal maps (fig. 12) illustrate diagrammatically the number and distribution of the setae present on the cuticle of the full-grown larva. These maps have been drawn up according to Fracker's method (1915), in which each segment of the larva is represented by a rectangle, the upper side of which corresponds to the mid-dorsal line and the lower side to the mid-ventral line.

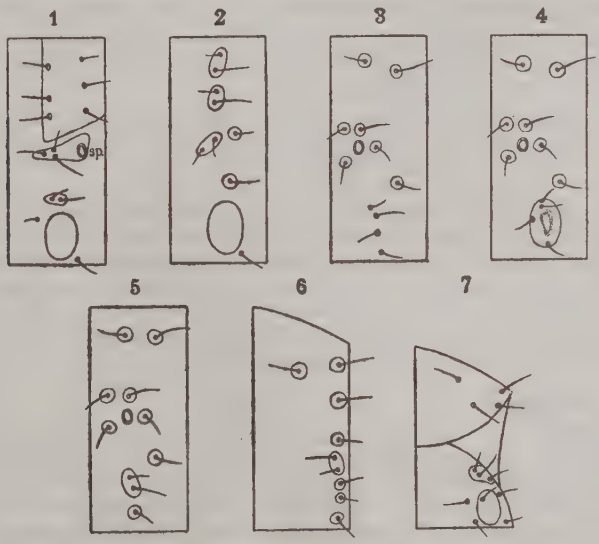

Fig. 12. Setal maps of full-grown larva: 1, prothorax; 2, mesothorax and metathorax; 3, abdominal segments i and ii; 4, abdominal segments iii, iv, v, and vi; 5, abdominal segments vii and viii; 6, abdominal segment ix; 7, abdominal segment x; sp = spiracle.

Fracker does not figure any segments of a species representing the family LYONETIIDAE, but sets down certain characters for the family drawn from two American species which were studied. His findings generally agree with the characters observed in *Hieroxestis subcervinella*. He states, however, that the "generalised but obscure characters of this family make the genera and species difficult to distinguish." It is rather curious to note how closely the setal arrangement of the species under consideration agree with that described and figured by Fracker for *Pseudanaphora arcanella*, a representative of the family ACROLOPHIDAE (or ANAPHORINAE). This family includes some of the most primitive of the Microlepidoptera and is grouped with the family LYONETIIDAE by Fracker, under the superfamily Tineoidea.

In the setal arrangement distinguishing characters are as follows: A trisetose group on the prothorax, anterior to the spiracle. On the abdominal segments 1–8, the anterior of the two setae which occur on either side of the mid-dorsal line is nearer the dorsum than the posterior one. Of the four setae which surround each abdominal spiracle, the first occurs immediately dorsal to the spiracle; a second is anterior to and on a level with the first; a third is immediately posterior to the spiracle; and the fourth is ventral and somewhat anterior to the spiracle. Fracker (*l. c.*) says that this last seta (which he calls *eta*) is located between the spiracle and the third seta but is more ventral in position. This character, however, does not hold good for *Hieroxestis*.

With regard to the grey-brown patches, mentioned previously, occurring on the cuticle of the larva, the distribution of these may also be followed from the setal maps. Fracker states that "It (a seta) is often surrounded by a small and definitely bounded chitinised area or pinaculum (Latin, *pinax*, dim., 'a small plate'), such as is seen in many microlepidoptera." These chitinised areas, or pinacula, are represented in the maps by lines drawn around the seta or setae which arise from them. In some instances setae lack this surrounding line and therefore do not have their origin on a pinaculum.

On microscopic examination the cuticle of the larva is found to be clothed with minute spines, but these spines are entirely lacking from the prothoracic shield, the suranal plate and each of the chitinised areas.

Internal Anatomy.—The internal anatomy, which was also examined, was found to correspond with that generally encountered in Lepidopterous larvae and in consequence is not subject to detailed description in this paper. The digestive system is of the relatively simple type, the alimentary canal consisting of an almost straight tube of unequal diameter. It is devoid of diverticula but possesses six Malpighian tubes, three opening by a common duct on either side into the hind intestine. The common duct bifurcates, and one of its branches subsequently divides into two, thus producing the three tubes to a side. The silk glands are conspicuous appendages forming two cylindrical tubes as long as the alimentary canal. The nervous, circulatory and respiratory systems also agree with the types generally encountered in Lepidopterous larvae and call for no special mention.

8. Habits of the Larva.

The caterpillars are voracious feeders and construct long meandering galleries, which they tunnel out in the parts of the plant they attack, large and conspicuous entrance and exit holes showing on the outside of the affected part. They spin while feeding and very soon construct a network of threads which collects and entangles the excrement and frass. The larvae were often observed to drop from a spun thread. When disturbed the caterpillar has a peculiar habit of twisting itself about very quickly and soon removes itself from the disturbing agent, head end or tail end first. When the head is touched a drop of blackish-brown fluid is frequently ejected; this would appear to be due to the expulsion of the banana sap that is ingested during feeding, which owes its colour to tannic acid. The caterpillars typically feed internally, but it was frequently found that a silken tunnel had been woven, covered over with excrement and other debris, and the larva was living within. When disturbed the caterpillar would emerge from the tunnel and then rapidly retreat back into it.

In captivity caterpillars on a few occasions mined into the corks of collecting tubes and there pupated.

9. Methods of Pupation.

The cessation of feeding is the first evidence of the change from the larval to the pupal state. The larvae, as a rule, pupate in the place where they have fed. The body becomes contracted and somewhat distended, the contents of the alimentary

canal being voided. Spinning follows, and a definite cocoon is formed in which the pupa lies. The cocoon (Plate iv, fig. 1) is 12–15 mm. long and 3·5 mm. in diameter and is composed of an intricate network of fine white silken threads. It is rounded at both ends and covered with frass and other debris, including fibres from the banana plant. In many cases the extreme ends of the cocoon are only covered by the spun threads and show as small whitish patches. The cocoon is usually attached to some part of the banana plant by one side, the covering of foreign particles, which may be incorporated in the silk threads, making it often difficult of detection. In many cases the cocoon is constructed within the gallery mined by the larva, just at the exit. The actual spinning operations take about a day, times varying from 17 to 22 hours having been observed. The final larval moult occurs soon after the completion of the cocoon, and the exuviae may be found lying at the hind end of the cocoon on its being opened.

10. Description of the Pupa.

At first of a pale yellow colour, the pupa rapidly darkens to orange and later to golden brown, the head and anal ends being distinctly darker, almost black. As the pupa matures, the eyes, antennae and thoracic appendages of the imago become more evident. The size varies from 7·5 to 11 mm. the average length being 9 mm.; the greatest width, which occurs at two-thirds of the length from the head end, is 2·1 mm. The breadth across the region of the genital openings is 1·2 mm. The males generally are somewhat smaller than the females, although this is not a constant feature.

Viewed from the dorsal or ventral surface it is subparallel-sided with a distinctly narrowed hind region. In lateral aspect it is plano-convex, the ventral surface being almost straight and the dorsal surface distinctly curved. The surface of the body is shining and smooth, except for definitely placed setae and rows of bristles. The intersegmental divisions of the abdomen are distinct. Abdominal segments 5, 6 and 7 in the male and 5 and 6 in the female are movable.

Dorsal Aspect (Plate iv, fig. 2).—The head, pro- and meso-thorax are minutely pitted, the mesothorax bearing on its posterior half striae which tend to run in a lateral direction. There is a distinct narrow strip, without punctures or striae, running the whole length of the mesothorax in the median line. The metathorax and following abdominal segments are smooth. The first abdominal segment bears no setae. Segments 2–9 inclusive each bear two setae, each of which is lateral in position and is situated near to the anterior border of the segment. These setae, arising from pits, are small, hair-like and brownish. Segments 4–8 inclusive bear a row of short stiff points on a slight ridge which is situated on the extreme anterior margin of each segment, adjacent to the intersegmental line. Each ridge of points extends completely across the dorsum. The backwardly directed tooth-like points are longest and stoutest in the middle, becoming smaller as they approach the sides. The ridge on segment 8 bears only a few scattered points. The cremaster consists of two prolongations of the dorsum of segment 10. These are stout at the base, gradually narrowing to form a pointed apex. Both structures are curved to form horn-like appendages pointing dorsally.

Ventral Aspect (fig. 13).—The clypeus bears a pair of close-set setae at each of the two postero-lateral edges. The antennae extend slightly beyond the wings and reach the middle of the seventh abdominal segment. The tip of the proboscis extends to the middle of segment 8. The wings are irregularly marked with shallow pits and striae. The genital openings, which are described below, are situated on segment 8 or 9 according to the sex of the pupa. The anal opening is terminal on segment 10, and is not armed by any setae, but there are two rounded protuberances, one a little to each side of the opening and slightly anterior to it.

Brownish setae are again found, their arrangement being similar on segments 5–8 of the abdomen. Each segment has on its anterior half two groups of two sublateral setae. Segment 4 only presents the outermost seta of each group. All the remaining segments are devoid of setae.

Lateral Aspect.—Oval spiracles with a dark brown rim are visible on segments 2–7, a rudimentary one being present on segment 8 of the abdomen. Immediately caudal of each spiracle, situated in the mid-length of each of segments 2–8 inclusive, arises a short seta from a pit. On segments 1–8 inclusive, placed dorsally and quite close to the spiracle, arises another solitary seta which is very small. A fairly strong bristle is situated ventrally to each spiracle and at some distance from it on segments 3–8 inclusive. There are no other pleural setae.

Pupal Sex Characters.—The work of Poulton (1890) and Hatchett-Jackson (1890) on Lepidopterous pupae has made it possible for the sexes of this stage to be determined. The examination of the pupae of *Hieroxestis subcervinella* with a hand-lens is sufficient to enable one to determine the pupal sex characters, which are describe below.

Fig. 13. Pupa; ventral aspect.

♂ (fig. 14).—Two closely-set rounded prominences occur near the posterior margin of the ninth abdominal sternite. Situated between these, in the mid-line, is a linear depression of a darker colour, usually black, corresponding externally to the internal termination of the pupal ductus ejaculatorius. The intersegmental line between segments 9 and 10 is distinct and continuous. Segment 10, besides bearing the two hooks of the cremaster, also bears two protuberances already described, but they need not be confused with those on segment 9 since they are situated widely apart and are larger and more evident.

♀ (fig. 15).—In this sex the intersegmental lines between segments 8 and 9, and 9 and 10, are not distinct and do not continue over the ventral surface of the abdomen. Segment 10, however, is distinguishable by the cremaster and the two prominences mentioned above. In the mid-ventral line of segment 9 occurs a short, somewhat narrow, dark depression indicating the termination of the oviducts. Poulton (*l. c.*) states that this depression, while existing in some cases on the ninth sternite, may also occur on the apex of the forward triangular projection of the tenth sternite. In all specimens of *H. subcervinella* examined it evidently was situated on the ninth sternite.

There is a bluntly triangular extension of the anterior part of sternite 9 which invades sternite 8. This extension appears as two slightly elevated triangular areas, between which and running forward through the whole length of sternite 8, is a second linear depression, which is, however, appreciably narrower than that on sternite 9. It also is dark in colour and indicates the opening of the bursa copulatrix. The two depressions were seen in all female pupae, and they were quite evident in several empty pupal cases which were examined.

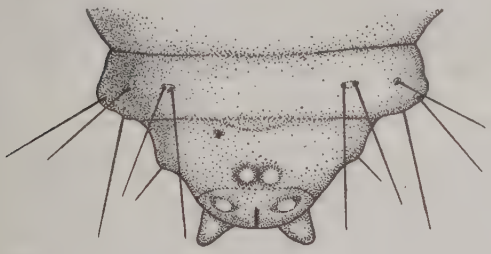

Fig. 14. Male pupa; ventral aspect of abdominal segments viii—x.

Fig. 15. Female pupa; ventral aspects of abdominal segments viii—x.

Both Poulton and Hatchett-Jackson state that these two depressions may either exist in some species as separate and distinct marks, or may, in others, coalesce and become so fused together as to become unrecognisable as two distinct depressions. Fisher (1924) in working on the pupae of *Tortrix pronubana*, Hb., found that " both [depressions] are fused to form one long slit-like aperture."

11. Duration of the Pupal Stage and Emergence of the Adult.

By the violent agitation of the rear abdominal segments and with the aid of the backwardly directed stiff points on the dorsum of segments 4–8, the pupa succeeds in forcing its way half or two-thirds out of the cocoon just prior to the emergence of the moth (Plate iv, fig. 1) The two horn-like hooks of the cremaster prevent the pupa from falling completely out of the cocoon, as they catch on the sides of the pupal envelope. The head and thoracic regions then dehisce and the moth escapes to remain in close proximity to the empty projecting pupal case until its soft chitinous integument has dried and hardened and the wings have expanded.

Dr. Edna Mosher (1916) in discussing the pupal characters of the superfamily Gracilarioidea mentions that " The LYONETIIDAE seem to be an exception to almost every rule. They have no free segments, the appendages are all soldered to the body, and there are no spines visible on the abdomen." While elsewhere we read " This family is a very difficult one to place satisfactorily by pupal characters alone, . . . " and " is another of the families which has been a source of anxiety to many lepidopterists." Finally, Miss Mosher also states that " The LYONETIIDAE do not spend their pupal life within the mine, nor in a cocoon, but are exposed and fixed by the caudal end to some cross threads on the under surface of the leaf (Clemens, Tineina of N. America, 1872, pp. 189–191)."

The reader will observe from the descriptions and notes on the pupa of *H. subcervinella* that it does not entirely conform with the general characters of the LYONETIIDAE, since certain of the abdominal segments do bear spines, and moreover some are definitely movable. In addition the pupa is enclosed within a cocoon, and the pupal life in many cases is spent within a mine.

According to Chapman's observations (1893) *Lyonetia* pupa has no free segments and the appendages are adherent to all the abdominal segments. It would appear, however, that *Hieroxestis* pupa approaches most nearly to the characters laid down by Chapman for the LITHOCOLLETIDAE and GRACILARIIDAE.

Specimens kept indoors under control (at Arucas, Gran Canaria) were found to agree very closely in regard to the length of the pupal period with those under observation in the plantation outside. The minimum period recorded was 16 days and the maximum was 20, the average being 18 days. During the period of observations on the emergence of the moth a careful temperature record was kept. The difference in the temperature out-of-doors and that in-doors was so small (about 2° F.) as to be negligible, and the variation during the whole period was found to be only 3·7° F.; 71·1° F. was the minimum and 74·8° F. the maximum temperature recorded.

12. Host-plants of H. subcervinella.

In Mauritius *Hieroxestis subcervinella* has been noted by Walsingham (1907) and Durrant (1925) as injurious to developed sugar-canes, and it also occurs there in potatoes and other stored tubers. In the Canaries the principal host-plant was the Canary or Chinese banana (*Musa cavendishii*, Paxt.), although a few specimens of *Musa sapientum*, L., encountered were also affected. Though sugar-cane is not now widely grown in the islands, the writer found the caterpillars in canes examined in the islands of Gomera and Gran Canaria. A small number of damaged maize plants were examined and showed signs of attack; in one specimen the caterpillar was found at work. Bamboo was also mentioned, in Gomera, as being attacked.

H. subcervinella, though a primary enemy of the banana in the Canary Islands, is to some extent a feeder on rubbish, and it would appear that other members of this genus have a similar habit.

13. Nature of Injury.

After a thorough examination of several plantations the caterpillars were found to be living in nearly all parts of the banana plants except in the actual roots and leaf blades. The worst damage was being done in the inflorescence. The larvae, which have the habit of allowing themselves to drop on spun threads, seldom feed exposed but burrow into the substratum, and the most characteristic indication of their presence was the accumulations of frass and excrement on the surface of the injured part. Since the caterpillars have the habit of spinning silk while feeding, the excrement was frequently observed entangled and spun together by the threads. The caterpillars apparently dislike feeding exposed and were seldom found on the surface of the plant. They either mined within the particular part on which they were feeding or constructed a silken tunnel as a shelter place, this being, as a rule, concealed by the entangled masses of excrement. All parts of the inflorescence were infested. A favourite feeding place was the distal end of the inflorescence, composed of nearly all male flowers. This part formed a close withered mass which afforded excellent shelter to the insects. Towards the basal part of the inflorescence, where the female flowers occur and where the edible fruit is later found, much damage was done by the larvae mining in the actual banana fingers. They gained entrance to the finger by mining through the narrow portion which connects the fruit to the inflorescence axis and, in a certain number of cases, the damage was so considerable that the banana fingers were merely hanging to the axis by a slender connection. Often a whole row of bananas (a 'hand') was so found owing to the larvae having mined round the axis in a horizontal direction immediately beneath the origin of the 'hand.' At times the distal ends of the fingers were damaged. It is the practice in banana cultivation in the Canary Islands to remove the flower parts from the young undeveloped ovaries, and where this is neglected rotting often occurs and so an

excellent opening for the larvae is presented. This means of entrance into the banana finger was often seized upon by the caterpillars, which ate their way into the fruit pulp towards the inflorescence axis. Out of hundreds of fingers examined the presence of larvae within them was almost always an easy matter of determination, as some external indication was found, such as accumulations of excrement, entrance and exit holes, and apparent rotting while still green and unripe. The numbers of caterpillars inside a finger varied considerably, but in one case the writer extracted 23 individuals from the fruit pulp of a single finger.

The inflorescence axis is subject to damage throughout its exposed length, and the larvae were found within it from its distal end to the thick basal part which emerges from the top of the ' stem.' In fact the part of the axis which emerges from the top of the plant, and is covered to some degree by the sheath of the innermost leaf, was the seat of much damage in many cases.

Apart from the frequency of larvae in the inflorescence, considerable injury was also observed in the outer leaf-sheaths constituting the stem-like mass. There the caterpillars were also found tunnelling and, as before, the accumulations of frass and holes indicated their presence. Several pieces of the rootstock which were dug up from the soil or which projected a little above the surface also showed injury but not to such a marked degree as in the other parts of the plant.

In captivity larvae fed on parts of the leaf-blade supplied to them, but under natural conditions the leaf-blades were free from attack.

Cultural operations vary slightly throughout the islands, and while in some localities the plant is cut down almost level with the soil surface after the banana bunch has been harvested, in other situations a stump of two or three feet in height is left. This latter course is practised to a certain degree in the island of Gomera, especially by Spanish cultivators, and an examination of such stumps showed the larvae to be present in great numbers. These stumps were gradually rotting and held much water in their centres, which had become hollowed out and yielded larvae mining in the cup-like rims of the stumps. Numbers of rat-tailed maggots (*Eristalis*) were also taken from the water which had collected in the centre of the stump.

The initial stage of the bunch of bananas is a flower-bud which grows from a central stem and forces its way up through the ' stem ' to the extreme top. When this bud becomes visible, at the top of the plant, it is said, amongst the growers, to be ' born.' From information gathered from the cultivators it appeared that the fruit ' born ' in May, June, and July became more heavily infested by the insect than fruit ' born ' in other months. Such fruit is harvested in September to November or December, and this coincides with the writer's observations, since the plants showing the most damage were those whose bunch of fruit was due to be harvested in these months. The combined experiences of many growers who were questioned points to the fact that they roughly consider that bunches collected from September to December are 100 per cent. infested, and those harvested in April to June are only 25 per cent. infested.

In those specimens of sugar-cane which were examined the attack was evident, as in the banana, by the entrance and exit holes of the larva and by the accumulations of entangled excrement. Infested canes which were split open (Plate v, fig. 1) disclosed the borings of the caterpillars within the cane, the galleries running often the whole length of an internode and, in cases, piercing the septum at a node. It was said by growers that the caterpillar attacked the cane from the bottom, but that later it might be found drilling the cane in any part.

Maize is also subject to the attacks of this species, both grain and stem being damaged. Tunnelling occurs, as before, and often a whole vertical line of grain on the cob becomes damaged owing to the working of the larva beneath. The number of maize plants which were infected was very small.

A Spanish grower, likely to be correct in his observations, informed the writer that the bamboo cane was also attacked, the leaves and canes being perforated, but there was no opportunity of confirming this in the field.

The severest damage done to the banana plant is due to the destruction of the tissue in the developing bunch. The pulp of the individual fingers becomes partly destroyed, while the entrance and exit holes of the tunnels afford points of attack by fungus diseases, thus rendering the fruit useless as food. While particularly susceptible to bruises, the Canary banana looses its wholesome properties as an edible fruit when its skin becomes pierced or broken, since rotting sets in soon afterwards. As every care is taken during the sorting and grading, previous to packing, to cut out all diseased fruit, extensive damage by the caterpillar results in the removal of so many bananas that the number of fingers remaining on the bunch may fall considerably below the normal.

While the working of the larvae in the distal end of the bunch amongst the non-developing male parts does not result in commercial loss, it follows that this place is a perfect breeding spot for the insect, which later may migrate and injure other valuable parts of the plant. In certain plantations this part of the bunch was cut off while the fruit was still maturing and used for fodder, but in others it was left remaining, as the grower considered that its removal would cause too profuse ' bleeding' of the sap.

The mining of the caterpillars in the inflorescence axis may be so severe, especially in the region from which the ' hands ' spring, that the flow of sap may be badly interrupted and the development of the fruit checked or retarded. Moreover, the workings of the larvae may be so extensive in the proximal portion of the axis (Plate v, fig. 2) that it is materially weakened and rendered unfit to bear the weight of the developing bunch. In fact in some plantations in the island of Gomera it was said that this weakening of the axis, combined with occasional strong winds, resulted in the breaking off from the plant of the entire bunch, which fell to the ground and proved a loss.

The borings of the caterpillars in the ' stem 'of the plant result to a certain extent in the loss of sap through the entrance and exit holes. When the leaf bases are perforated the sap exudes in a copious flow until the pressure within is reduced, the amount of sap that exudes decreasing until but little escapes after several days.

Owing to the remarkably equable climate enjoyed in the Canary Islands, banana production is uninterrupted, with the result that the insect injury is continuous, although it is more severe at certain seasons than at others.

14. Parasites.

During the course of the work no indications of the attacks of parasites on any stages of the pest were observed, and it would appear that *H. subcervinella* up to the present is comparatively free from parasites in the Canary Islands. In the literature dealing with the moth under consideration no mention is made of any parasitic natural enemies. As the insect appears to be apodemic in the Canary archipelago it evidently has been introduced without parasites that might have attacked it successfully. If this be the case, then the introduction of a parasite might be attended with beneficial results.

15. Acknowledgments.

In conclusion the writer wishes to express his indebtedness to Dr. R. Stewart MacDougall for his advice and encouragement during the work, which has been carried out under his supervision. Thanks are due to the late Mr. J. H. Durrant for his kindness in supplying the information regarding the synonymy, distribution and host-plants of

the insect contained in the article published in the "Entomologist's Monthly Magazine" (1925). To Mr. R. H. Rush and other British members of the staff of Messrs. Fyffes, Ltd., in the Canary Islands, thanks are due for their helpful advice and information and for the many facilities which were so willingly granted in aiding the field work to be pursued. Acknowledgment is also made to Señor Armas Gourié, of Arucas, Gran Canaria, and several other Spanish cultivators who volunteered information on this pest.

16. Summary.

The moth, *Hieroxestis subcervinella*, Wlk., has recently become a pest of economic importance to the banana cultivators in the Canary Islands.

Notes on the genus *Hieroxestis* and on the synonymy and distribution of the moth are included, and descriptions of the various stages of the insect are given. Details regarding the external morphology and chaetotaxy of the full-grown larva are enumerated, and setal maps showing the distribution of the setae have been added.

The pupa is described in detail, and sex characters are noted.

The economic importance of the pest is considered in its relation to its host-plants, while its method of attack and resulting injuries caused are discussed.

The insect is considered as apodemic in the Canary Islands, and no parasitic natural enemies were encountered.

References.

Back, E. A. & Pemberton, C. E. 1916. "Banana as a host fruit of the Mediterranean Fruit Fly."—J. Agric. Res., Washington, v, no. 17, pp. 793–803.

Butler, A. G. 1876.—Ann. Mag. N.H., (4) xvii, p. 409.

Chapman, T. A. 1893. "On some neglected points in the structure of the pupae of Heterocerous Lepidoptera, etc."—Trans. Ent. Soc. London, pp. 97–119.

Cook, M. T. 1913.—"The Diseases of Tropical Plants."—MacMillan & Co., Ltd., London.

Cockerell, T. D. A. 1923. "The Lepidoptera of the Madeira Islands."—The Entomologist, lvi, p. 247.

Durrant, J. H. 1923. "A moth from Saint Helena in Britain."—Proc. Ent. Soc. London, p. xvii.

Durrant, J. H. 1925. "The Banana Moth, *Hieroxestis subcervinella*, Wkr."—Ent. Mon. Mag., lxi, pp. 12–13.

Fawcett, W. "The Banana, its Cultivation, Distribution and Commercial Uses."—Duckworth & Co., London. 2nd Edition.

Fisher, R. C. 1924. "The life-history and habits of *Tortrix pronubana*, Hb., etc."—Ann. App. Biol., xi, nos. 3 & 4, pp. 395–447.

Fracker, S. B. 1915. "The Classification of Lepidopterous Larvae."—Illinois Biol. Monog., ii, no.1.

Hatchett-Jackson, W. 1890. "Studies in the morphology of the Lepidoptera. Part 1."—Trans. Linn. Soc. London, Zoology, (2) v, pt. 4, pp. 143–186.

Melliss, J. C. 1875. "St. Helena, a Physical, Historical, and Topographical description of the Island."—Reeve & Co., London. p. 192.

Meyrick, E. 1892.—Proc. Linn. Soc., N.S.W., xvii, pp. 482, 567–568 (sp. 139).

Meyrick, E. 1910.—Trans. Ent. Soc. London, p. 375.

Meyrick, E. 1911. "Tortricina and Tineina."—Trans. Linn. Soc., London, Zoology, (2) xiv, pt. II, pp. 263–298.

Meyrick, E. 1923.—Trans. Ent. Soc. London, p. 556.

Mosher, E. 1916. "A classication of the Lepidoptera based on characters of the pupa."—Bull. Illinois State Lab. Nat. Hist., xii, art. 2.

POULTON, E. B. 1890. "The External Morphology of the Lepidopterous Pupa, etc. Pts. I–III."—Trans. Linn. Soc., London, Zoology, (2) v, pt. 5, pp. 197–202.

SWEZEY, O. H. 1909. "The Hawaiian Sugar-cane Bud Moth (*Ereunetis flavistriata*), with an account of some allied species and natural enemies."—Bull. Exp. Stat. H.S.P.A., vi, pp. 17–18.

SWEZEY, O. H. 1910. "The feeding habits of Hawaiian Lepidoptera."—Proc. Hawai. Ent. Soc., ii, p. 142.

SWEZEY, O. H. 1922. "*Hieroxestis omoscopa*, Meyr."—Proc. Hawai. Ent. Soc., v, p. 9.

TRÄGÅRDH, I. 1913. "Contributions towards the comparative morphology of the trophi of the Lepidopterous leaf-miners."—Ark. f. Zool., viii, no. 9.

WALKER, F. E. 1863.—Cat. Lep. B.M. xxviii, pp. 477–8 (sp. 78).

WALSINGHAM, Lord. 1907.—"Fauna Hawaiiensis," i, pt. 5, p. 713.

WILLIAMS, C. B. 1923. "A New Type of Light Trap for Insects."—Minist. Agric. Egypt Tech. & Sci. Serv., Bull. xxviii.

WOLLASTON, T. V. 1879. "Notes on the Lepidoptera of St. Helena, with descriptions of new species."—Ann. Mag. N. H. (5) iii, p. 417.

Fig. 1. Two empty pupal cases of *Hieroxestis subcervinella* protruding from the cocoons.

Fig. 2. Pupa of *H. subcervinella* ; dorsal aspect.

FLEAS FOUND ON RODENTS AND INSECTIVORES IN NIGERIA.

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During the latter half of the year 1926, the writer collected parasites from rodents and insectivores in Nigeria. From 1st August to 20th October collections were made in the wet forest near Lagos; 26th October to 2nd November and 10th to 20th November in the guinea grass savannah near Ibadan and Oyo; 3rd to 7th November in the heavy rain forest at Ife; and 28th November to 11th December about Kano on the border of the desert. The animals were usually captured in traps, but a few were shot. They were always placed at once in tight cloth bags or wire cages in order that their ectoparasites might not escape. A general account of the character of the country where collections were made has been given elsewhere (Pearse, Science Monthly, xxv, 1927, pp. 228–239). My thanks are due to the late Major Ingoldby, of the British Museum, and Dr. Karl Jordan, of the Tring Museum. The former identified all the mammals and the latter helped with the identification of several of the fleas.

The general results of the investigations are shown in Table I. It will be noticed that all hedgehogs (*Atelerix*) were infested with fleas, and that four species of fleas were represented on these animals. The desert Gambian rats (*Cricetomys buchanani*) show a heavy infestation, but no fleas were found on those living in the forest near the coast (*C. emini*). The desert animals in most cases were heavily infested with fleas; those in the guinea grass showed a moderate degree of infestation; and those in the forests had little or none, except the black rat, *Rattus rattus*, which usually occurred in native houses.

The desert Gambian rats (*C. buchanani*) lead in number of parasites per individual (29). These live in burrows and inhabit a dry country where fleas are abundant. The hedgehogs come next (5·5, 2·8) and are followed closely by the widely distributed and ubiquitous shrew, *Crocidura manni*. The animals that show little or no infestation are those which live in the forests. Large animals usually support more fleas than small, but in the forest the largest animals studied (*Cricetomys, Thrynomys*) had no fleas, though they were heavily infested with ticks. The writer took two chigoe fleas from his own toes while working near Lagos, but found none on the rodents in the same locality. In the coastal region the only rodents which showed a significant number of fleas were the black rats, an abundant tree squirrel (*Funisciurus anerythrus*), and a little striped mouse (*Lemniscomys striatus*), which lived in grassy fields. The smallest rodent examined (*Leggada musculoides*), though occurring in favourable situations, carried no fleas.

The ecological factors which are associated with a high degree of infestation are dry climate or habitat, the occupation of a more or less permanent home by the host, and large size of the host. Factors associated with low degree of infestation are wet climate or habitat, lack of permanent abode of host, small size of host, and wandering or arboreal habits of host.

Some species of fleas (*Xenopsylla cheopis, Echidnophaga gallinacea, Ctenocephalus canis*) were found on a variety of hosts. Others were quite restricted in their distribution (*Xenopsylla nubicus, Synosternus pallidus, Ceratophyllus consobrinus*).

During the time the writer was working in Nigeria, plague was quite prevalent in Lagos, and over four per cent. of the rats were infected. None of the rodents reported in this paper were collected in the city of Lagos, but 356 of them were collected in the forests, fields, and villages within ten to fifteen miles of the city. Careful

watch was kept for evidence of plague in all rodent post mortems and none was found. In a few cases which looked suspicious smears were made from spleens, but no bipolar bacilli were found.

The results indicate that in Southern Nigeria, where the climate is very wet, fleas do not commonly occur except on house rats (*Rattus rattus*), which live in comparatively dry habitats in mud houses. Plague is therefore probably not spread to any extent by "bush" rodents, which live in the forest or in the fields of the natives. In the North, where the climate is dry, there are many fleas, but as yet plague has not been introduced.

TABLE I.

Fleas found on Nigerian Rodents and Insectivores.

Ib, Ibadan; If, Ife; K, Kano; L, Lagos; +, less than half of one-tenth of one per cent.

	Locality.	Number examined.	*Ceratophyllus consobrinus.*	*Ctenocephalus canis.*	*Ctenocephalus cophirus.*	*Echidnophaga gallinacea.*	*Synosternus pallidus.*	*Xenopsylla cheopis.*	*Xenopsylla aquisetosus.*	*Xenopsylla nubicus.*	Unknown.	Total.	Per cent. infested.	Parasites per individual.
Aenomys hypoxanthus ...	If	1											0	0
Arvicanthus mordax	K	9						3 7				3 7	33	0·8
Arvicanthus rufinus	Ib If	6		1 2								1 2	17	0·3
Atelerix spiculus	K	5		4 8		1 1	4 4	1 1				10 14	100	2·8
Atelerix spinifex	K	2		1 5			2 6					3 11	100	5·5
Cricetomys buchanani ...	K	10				3 256		5 12	2 22			10 290	70	29·0
Cricetomys emini	If L	18											0	0
Crocidura sp.?	Ib L	15											0	0
Crocidura manni	Ib KL	19				1 11		5 39	1 15			7 65	32	2·8
Euxerus erythropus moestus	L	2											0	0
Funisciurus anerythrus ...	Ib If L	12	1 3									1 3	8	0·3
Funisciurus auriculatus olivae	L	5											0	0
Heliosciurus isabellinus ...	L	3											0	0
Hybomys univittatus	L	44									1 1	1 1	2	+

TABLE I.—*continued.*

Fleas found on Nigerian Rodents and Insectivores.

Ib, Ibadan; If, Ife; K, Kano; L, Lagos; +, less than half of one-tenth of one per cent.

	Locality.	Number examined.	*Ceratophyllus consobrinus.*	*Ctenocephalus canis.*	*Ctenocephalus cophrus.*	*Echidnophaga gallinacea.*	*Synosternus pallidus.*	*Xenopsylla cheopis.*	*Xenopsylla aquisetosus.*	*Xenopsylla nubicus.*	Unknown.	Total.	Per cent. infested.	Parasites per individual.
Leggada musculoides ...	Ib LK	47											0	0
Lemniscomys striatus ...	Ib If L	24									1 2	1 2	4	0·2
Lepus zechi	Ib	2											0	0
Lophuromys sikapusi ...	Ib If L	11											0	0
Malacomys edwardesi ...	L	20											0	0
Mastomys sp.?	If	4						1 1				1 1	25	0·3
Mastomys erythroleucus ...	Ib L If K	31						1 1				1 1	3	+
Mus musculus	L	3											0	0
Praomys tullbergi	L	96			1 1							1 1	1	+
Protoxerus strangeri nigeriae	If	1											0	0
Rattus rattus	If L	79						15 22				15 22	19	0·3
Taterillus gracilis angelus ...	K	9								3 5		3 5	33	0·5
Taterona kempi	Ib K	26						1 1		1 1		2 2	8	0·1
Thrynomys swinderianus ...	L	1											0	0
Uranomys foxi	Ib	1											0	0
Lagos	L	356			1 1			15 22			2 3	18 26	5	0·07
Ibadan, Oyo	Ib	70						2 2		1 1		3 3	4·2	0·04
Ife	If	27	1 3	1 2				1 1				3 6	4·7	0·148
Kano	K	54		5 13		5 268	6 10	14 59	3 37	3 5		36 392	48·1	7·25

NOTES ON SOME CHALCID PARASITES OF LAC-INSECTS.

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Many parasitic Hymenoptera are already known to live on lac-insects, and they are of importance either as noxious insects by destroying the Coccid (*Tachardia lacca* (Kerr)), or as useful insects when parasiting the predators of lac. As a result of the studies of Cameron, Imms, Misra and Mahdihassan, something is already known about them, but the systematic position and the identity of many of the species are still uncertain.

We shall mention here only four species, which were received by the Imperial Bureau of Entomology from C. S. Misra, from India. Three of them are of special interest, as they are still little known, and we intend to give more detailed descriptions to facilitate their identification.

Family Encyrtidae.

1. Tachardiaephagus tachardiae (How.).

Encyrtus tachardiae, Howard 1896.

Tachardiaephagus thoracicus, Ashmead 1904 (new syn.).

Lissencyrtus troupi, Cameron 1913 (new syn.).

Several females bred from lac on *Zizyphus jujuba* (Nankom, Bengal) were examined and compared with the type of *Lissencyrtus troupi*, Cam. Dr. A. B. Gahan, of the U.S. Bureau of Entomology, had the kindness to compare some of these females with Ashmead's type of *Tachardiaephagus thoracicus*, and finding them identical with this species as well as with the *Encyrtus tachardiae* of Howard, called our attention to the above synonymy.

This species is well known and has been recognised by all students of lac-insects. Good coloured figures of the male and female have been given by Imms and Chatterjee, who give also a description of the male. Mahdihassan has also published interesting information about it and mentions another allied species, which he names *Lissencyrtus somervilli* ; but this must be included also in the genus *Tachardiaephagus*. This species can be distinguished from *T. tachardiae* (How.) especially by the colour of the head, which is orange-yellow, like the thorax, instead of dark.

Family Elasmidae.

2. Elasmus claripennis (Cam.).

Cyclopleura claripennis, Cameron 1913.

Elasmus colemani, Mahdihassan 1923 (new syn.).

♀. Length 3 mm. Face and vertex finely punctate with some larger scattered points. Lateral ocelli separated from the eye-margin by a space three times as long as their diameter. Antennae with the pedicellus shorter than the funicular joints ; these are about three times as long as broad, the 2nd only a little longer than the 1st and 3rd ; club 3-jointed, somewhat longer than the 2nd joint of the funicle. Pronotum without a transverse carina ; mesonotum finely punctate and covered with short black hairs ; scutellum and propodeum slightly rugulose, without hairs, the propodeum without median carina and with small rounded spiracles. Wings hyaline with a faint brownish cloud around the stigma, and reaching not quite to the end of the abdomen. Abdomen elongate and pointed, almost twice as long as the thorax. Ovipositor very short.

Black, with a green reflection, especially on the head, mesonotum and propodeum ; the scutellum and the sides of the thorax more bluish-violet, Antennae brown, scape yellow. The axillae, a point on each side of the mesonotum beside them, and the postscutellum, yellow. Abdomen dark brown, with the base of the 1st segment greenish ; the end of segments 1 and 2, the base of segments 3 and 4, and the sides of the abdomen, reddish-yellow. Legs pale yellow, almost whitish, except the base of the middle and hind coxae, which is greenish black, and a small black stripe on the upper part of the hind femora. The tibiae with rows of black hairs ; on the hind tibiae they form four regular lozenges (fig. 1, *a*).

♂. Length 1·7–2·2 mm. In structure and colour similar to the female. Antennae with 3 long branches. Abdomen much shorter, as long as or shorter than the thorax ; the end of the 1st, the 2nd and the base of the 3rd segment reddish-yellow, more or less black above ; the remaining segments black. Legs darker ; the base of all the coxae and the middle and hind femora (except base), black. On the hind tibiae the black hairs are arranged as in the female.

♀ and ♂ bred from larvae of *Eublemma*, a Noctuid predacious on lac occurring on ***Zizyphus jujuba***, Nankom, Bengal.

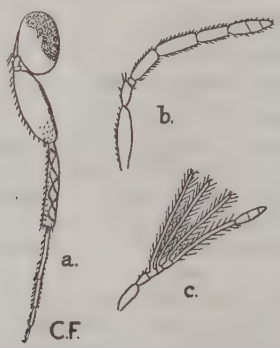

Fig. 1. *Elasmus claripennis* (Cam.) : *a*, hind leg ; *b*, antenna of female ; *c*, antenna of male.

The description of the genus *Cyclopleura*, Cameron, sufficiently indicated its relationship to *Elasmus*, and, as Mahdihassan says (1925), Waterston wrote to him : " I have long regarded *Cyclopleura* Cam. as a synonym of *Elasmus*." Cameron's type is in the British Museum, and we are able not only to confirm the synonymy of the genera, but also to say that *C. claripennis*, Cam., bred from lac at Dehra Dun, Northern India, is exactly the same species as the ♀ specimen of which we give here the description.

We identify also our *Elasmus* with *Elasmus colemani*, Mahdihassan, which the author bred from larvae of *Eublemma amabilis*, Moore, and mentioned without description. He said only (1923) : " It is allied to *Elasmus articles* described by Walker in 1843 from a specimen collected in Bombay and differs in having smoke-white legs instead of their being pitch-brown." In 1925 he speaks of two distinct species, saying that his *E. colemani* has " lozenge-shaped three cells on the hind tibiae formed by hairs so arranged, while the other species which I designate *E. claripennis* has two irregularly shaped rows of hairs not forming any cells." We have seen that the type of Cameron has also lozenge-shaped cells on the hind tibiae, as have many other *Elasmus*, and the second species mentioned by Mahdihassan must be still another species.

E. claripennis (Cam.) differs also from *E. indicus*, Rohwer, especially by being larger and having the joints and club of the antennae more elongate, the scutellum darker, the abdomen more reddish yellow, and the legs almost quite clear instead of brown. It stands nearer *E. nephantidis*, Rohwer, another Indian species, by the form of the antennae, but differs especially by the hairs on the mesonotum being black (and not whitish), the propodeum a little rugulose (and not polished), the thorax darker, the abdomen with more brownish parts and the legs clearer.

Family Eulophidae.

3. Coccophagus tschirchii, Mahdihassan.

This is really a new species, which has not been described by Mahdihassan, but only referred to in a few words. We give here a description and a drawing.

♀. Length 1–1·2 mm. Head as broad as the thorax, vertex very short, eyes ciliate, lateral ocelli a little nearer to the eye margin than to each other. Cheeks as long as the diameter of the eyes. Antennae with 8 joints, inserted near the clypeus, scape elongate, pedicellus short, 1½ times as long as broad, 1st joint of funicle almost twice as long as the pedicellus, 3 times as long as broad, 2nd joint a little shorter, as

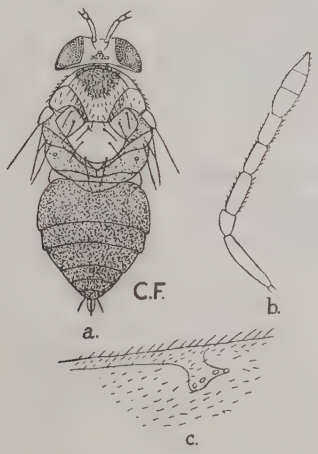

Fig. 2. *Coccophagus tschirchii*, Mahd.: *a*, dorsal aspect; *b*, antenna; *c*, stigmal nerve.

long as the 3rd, club with 3 joints, not much broader than the funicle and as long as the two preceding joints together. Thorax rounded, finely reticulated on the mesoscutum, the scutellum almost polished; parapsidal furrows well marked, axillae large, scutellum largely rounded behind. Propodeum short without lateral grooves, the spiracles small and rounded. Thorax more or less covered with black hairs, which are smaller in front and become larger behind; the mesoscutum with several rows of small hairs, one row on each lateral part along the parapsidal furrows, two longer hairs on each axilla and 6 long hairs arranged in pairs on the scutellum, the two posterior the largest. Wings broad, hyaline, reaching far beyond the end of the abdomen, covered with short ciliae, the fringes also very short. Marginal nerve much longer than the submarginal, stigma and postmarginal nerves very short. Abdomen as long as the thorax, rounded; 1st segment the longest, 2nd half the length of the 1st,

3rd a little longer than the 2nd, 4th short, transverse, the following shorter. Ovipositor very little exserted. Legs not broadened, normal ; spurs of middle tibiae as long as the metatarsus.

Head yellow, only the stemmaticum and eyes black. Antennae brown, the scape clearer. Thorax lemon-yellow, with the middle of pronotum and a rounded spot on the middle front part of the mesonotum black ; the axillae, the narrow parts between these and the parapsidal furrows, the sides of the thorax, and the propodeum, more or less brown. Abdomen black. Legs entirely light yellow.

Several ♀♀ obtained from lac on *Butea frondosa*, Kundari, Bengal.

Mahdihassan mentioned this species only in the following words (1923) : " There is at least one chalcid which so far I have not reared from any other insect than the Mysore lac insect. It belongs to the genus *Coccophagus* and is black and lemon-yellow in colour . . . It would be interesting to compare it with a similar black and yellow Apheline of this genus named *C. scutatus* by Dr. L. O. Howard." The coloration of the thorax is very peculiar, and the species is most nearly related to *C. scutatus*, How., from which it differs in the following characters :—

C. scutatus, How. Scutellum black ; mesonotum with a lemon-yellow stripe which goes from tegula to tegula ; legs more or less dark.

C. tschirchii, Mahd. Scutellum yellow ; mesonotum lemon-yellow with a large black spot near the pronotum ; legs entirely yellow.

Every specimen examined was a female. The males seem to be always very rare. Mahdihassan says (1925) : " The usual ratio between males and females is about one to fifty respectively. . . . In August, 1923, lac from Khonde Bhavi, Kolar District, in Mysore State, gave rise to hundreds of females without a single male."

4. Tetrastichus (Geniocerus) purpureus (Cam.).

Hadrothrix purpurea, Cameron 1913.

Tetrastichus immsii, Mahdihassan 1923 (new syn.).

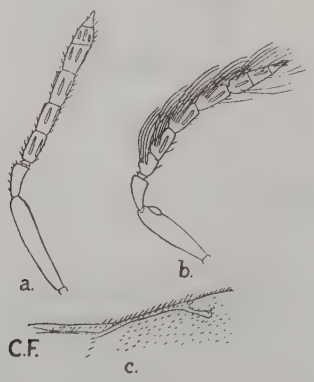

Fig. 3. *Tetrastichus purpureus* (Cam.) : *a*, antenna of female ; *b*, antenna of male ; *c*, wing nerves.

♀. Length 1·5–1·8 mm. Head shining, very slightly punctulate, rounded, vertex very short. Antennae elongate, scape reaching a little beyond the front ocellus ; the 3 funicle joints and the pedicellus nearly all of equal length, about twice as long as

broad; the club 3-jointed, as long as the two preceding joints together, the last joint short and pointed; ciliae short. Mesonotum and scutellum slightly reticulate, the median groove of the mesoscutum and the two longitudinal grooves of the scutellum well marked. Propodeum polished, with a small median carina and lateral grooves; spiracles small. Wings large, hyaline, reaching beyond the end of the abdomen. Marginal nerve longer than the submarginal; stigma as long as a third of the marginal nerve; submarginal nerve with 4 ciliae. Abdomen a little longer than the thorax, slightly broadened until beyond the middle, then sharply pointed. Ovipositor slightly protruding.

Black with purplish and greenish reflection. Base of abdomen more or less yellow. Antennae brown. Legs yellow; the base of the coxae, stripes above and below the femora, and the end of tarsi brownish. Marginal and stigmal nerves light yellow.

♂. Length 1·2 mm. Similar to female. Antennae with long bristles arranged in half-circles on the outer part of the funicle joints and almost twice the length of the joints; club 3-jointed, elongate and pointed; scape with a small rounded sense organ. Abdomen shorter than the thorax, with the 1st segment yellow. Legs clear yellow; coxae, part of femora, and end of tarsi brown.

Reared from lac on *Zizyphus jujuba*, Nankom, Bengal.

The type of Cameron's *Hadrothrix purpurea*, which he places among the APHELININAE, is also in the British Museum. It is in reality a male *Tetrastichus*, quite similar to those received from India. The "characteristic long, stiff bristles on the antennae and the long thin stigmal vein" are typical for many males of the TETRASTICHINAE, and we are astonished that Cameron did not notice the longitudinal grooves on the mesonotum and scutellum.

Imms & Chatterjee (1915, pl. viii, fig. 35) give a figure of a "common unnamed Chalcid bred from lac obtained from Siwalik forests." This figure has all the characteristics of the female of our *Tetrastichus*. Mahdihassan was the first to recognise that these Chalcids, which he also obtained in great numbers, were *Tetrastichus*, and he named them *T. immsii*, without giving any description. His only morphological reference to it was (1923): "The most common Chalcid enemy of lac insects on *Shorea* is a black insect allied if not the same as illustrated by Dr. Imms . . . It has not been described but it belongs to the genus *Tetrastichus* or to a closely allied one. I am hoping to receive some specimens reared by him, but provisionally, in honour of its discoverer, I have named it *T. immsii*." In his paper of 1925 he adds nothing to this, but confirms the fact that it is really the species illustrated by Imms & Chatterjee, and says that it is very abundant. "In Mysore lac it constitutes more than half the Chalcids reared at the end of the monsoon season" . . . "It has been found to have a very wide distribution." He confirms also that it is a direct parasite of the Coccid and not an hyperparasite.

This *Tetrastichus* having four ciliae on the submarginal nerve, belongs to the subgenus *Geniocerus*, Ratz. It appears to differ from all other species of *Tetrastichus* described from India, in particular from those described by Rohwer and Waterston.

References.

ASHMEAD, W. H. Classification of the Chalcid Flies of the Super-Family Chalcidoidea.—Mem. Carnegie Mus., i, no. 4, 1904. (*Tachardiaephagus*, p. 303).

CAMERON, P. On the parasitic Hymenoptera reared at Dehra Dun, Northern India, from the Lac (*Tachardia*) and Sal Insects.—Ind. For. Rec., iv, 1913, pp. 91–110.

GIRAULT, A. A. Notes on described Chalcidoid Hymenoptera with new Genera and Species.—Soc. Entom., xxxi, 1916, pp. 35–38; 42–44. (Description of *Tachardiaephagus thoracicus*, p. 43.)

HOWARD, L. O. & ASHMEAD, W. H. On some reared parasitic Hymenopterous Insects from Ceylon.—Proc. U.S. Nat. Mus., xviii, 1896, p. 633–648.

IMMS, A. D. & CHATTERJEE, N. C. On the Structure and Biology of *Tachardia lacca*, Kerr, with observations on certain insects predaceous or parasitic upon it.—Ind. For. Mem., Forest Zool. Ser., iii, pt.1, 1915, 42 pp., 8 figs.

MAHDIHASSAN, S. Classification of Lac Insects from a physiological Standpoint.—J. Sc. Ass. Maharajah's Coll., Vizianagaram, i, 1923, pp. 47–99.

MAHDIHASSAN, S. Some Insects associated with Lac and a symbolic Representation of their Relationship.—J. Sc. Ass. Maharajah's Coll., ii, 1925, pp. 64–87.

MISRA, C. S., The Cultivation of Lac in the Plains of India.—Agr. Res. Inst. Pusa, Bull. 142, 1923, 83 pp., 23 pls., 14 figs.

ROHWER, S. A. Description of new Chalcidoid Flies from Coimbatore, South India.—Ann. Mag. Nat. Hist., (9) vii, 1921, pp. 123–135, 9 figs.

APHIDIDAE FROM ITALIAN SOMALILAND AND ERITREA.

By Fred. V. Theobald, M.A., V.M.H., F.E.S.

The following Aphids were collected by Professor Guido Paoli, of Chiavari in Italian Somaliland and in Eritrea.

In the collection is a marked new genus which I have named after Professor Paoli and a new species of *Geoica* from the roots of *Zea mais*. An apparently new species of *Aphis* found on *Thespesia danis* is too damaged to describe. The remaining species are all common insects.

List of Aphids from Somaliland.

Macrosiphum jaceae, Linn., on *Carduus* (cultivated).
Aphis maidis, Fitch, on *Zea mais*.
Aphis tavaresi, Del Guercio, on *Citrus limonum*.
Aphis gossypii, Glover, on cotton and cucurbits.
Aphis ficus, Theob., on *Ficus sycomorus*.
Aphis laburni, Kalt., on *Phaseolus* and cotton.
Aphis, sp. nov. ? on *Thespesia danis*.
Paoliella hystrix, sp. nov., on *Commiphora savojae*.
Geoica pseudosetulosa, sp. nov., on *Zea mais* roots.

From Eritrea.

Macrosiphum jaceae, Linn., on *Carduus* (cultivated).
Macrosiphum pisi, Kalt., on *Phaseolus* (Cape variety).
Aphis maidis, Fitch, on *Zea mais*.
Aphis nerii, Boyer, on *Calotropis procera*.
Aphis gossypii, Glover, on cotton.
Aphis laburni, Kalt., on *Phaseolus*.
Brevicoryne brassicae, Linn., on *Brassica oleracea*.

Genus **Paoliella**, nov.

Body of apterous female with long, thick, backwardly projecting spines all over it. Head with two large projecting spines in front. Eyes minute, of 3 facets. Antennae of six segments ; iii the longest, slightly longer than vi ; flagellum of vi nearly as long as base. Cauda irregularly, but distinctly knobbed. Anal plate bifid, lobes more or less rounded. Cornicles as pores or very slightly elevated. Rostrum long. Legs short.

Named after Professor Guido Paoli.

This genus differs from *Shivaphis*, Das, in the longer flagellum, the minute 3-facetted eyes, the absence of leg glands, and in its markedly spiny nature ; from Van der Goot's *Glyphinaphis*, by the antennae of the apterae being of six not four segments, and by the cornicles. From the Oregmini it also differs in the six-segmented antennae. It apparently comes into the sub-tribe Callipterina.

Paoliella hystrix, sp. nov.

Apterous viviparous female. Very minute. Pallid ; legs slightly darkened. Eyes very minute, black and red, composed of three facets only. Body with many large long spines, projecting backwards, their edges notched or minutely spiny. Head broad, with two prominent, thick, straight, acuminate, projecting spines in front (very similar to those of *Oregma*). Antennae of six segments, much shorter than the body ; i a little wider but no longer than ii ; iii the longest, a little longer than vi ; iv and v equal, the latter with normal primary sensorium ; vi with base longer than

v; flagellum slightly shorter than the base, primary sensorium normal. Anal plate bilobed, the lobes more separated in some than in others; with two long and two short hairs on each lobe. Cauda knobbed, but of irregular form, with two long hairs apically and two shorter ones on each side. Cornicles as circular pores or very slightly elevated.

Fig. 1. *Paoliella hystrix*, sp. nov.: Apterous viviparous ♀ (greatly enlarged).

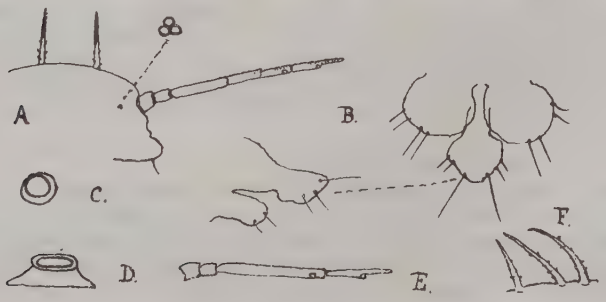

Fig. 2. *Paoliella hystrix*, sp. nov.: A, Head, antenna, eye of apterous ♀; B, Cauda and anal plate; C, Cornicle; F, Body hairs; D, Cornicle of *Glyphinaphis*; E, Antenna of *Glyphinaphis*.

Length, 0·5–0·8 mm.

Locality. Somaliland (Italian).

Food-Plant. *Commiphora savojae* (Chiovenda).

Described from a number of apterous females in spirit. With them were many larvae in all stages. It is a very minute insect, easily demarked by the long, thick

body spines, rather roughened at their edges, mostly sloping backwards, giving the little insect a porcupine-like appearance.

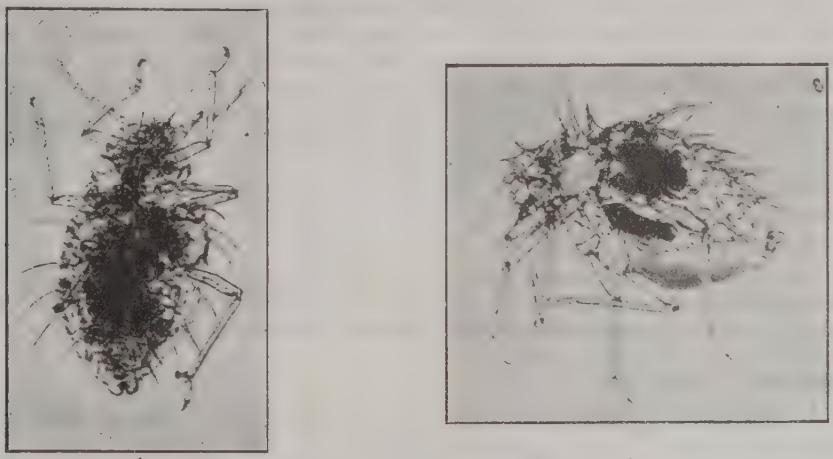

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Fig. 3. *Paoliella hystrix*, sp. nov. : 1, Dorsal, and 2, Lateral view, showing the spiny nature (much enlarged).

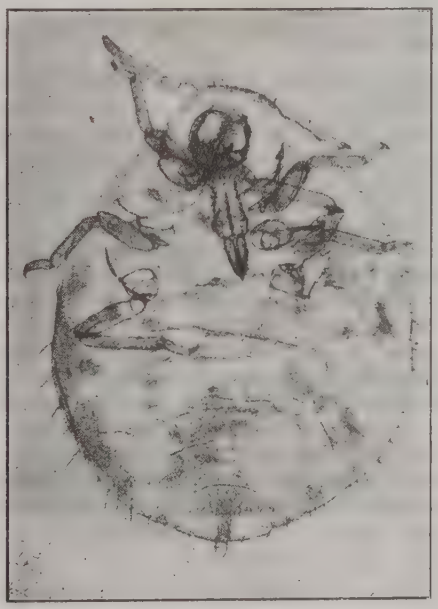

Fig. 4. *Geoica pseudosetulosa*, sp. nov. : Apterous viviparous ♀ (greatly enlarged).

Geoica pseudosetulosa, sp. nov.

Apterous viviparous female. Globular ; creamy white ; legs, genital plate and apices of antennae dusky ; apices of tibiae and the tarsi darkened. Rostrum brown,

apex dark. Body hairy; the lateral hairs much longer than those on the dorsum. Antennae short, of five segments; i and ii about equal, i slightly the wider; iii nearly twice length of i and about the length of v, in some not quite so long; v with a short, blunt nail; all the segments with a few curved hairs; primary sensoria normal, fringed. Head slightly convex in front. Eyes as minute black specks. Rostrum short and broad, reaching to 2nd or 3rd coxae; apical segment longer than the penultimate, with two long and several short hairs. Legs short and thick; rather long hairs on the tibiae and tarsi and a few on the femora, somewhat thinner than those on the tibiae. Tarsi of two segments.

Length, 1·6 to 2·0 mm.

Locality. Somaliland (Italian).

Food-Plant. *Zea mais* (roots).

Described from five apterous females found feeding on the roots of *Zea mais*. It resembles Passerini's *Geoica setulosa*, but the lateral body hairs are much longer, the apical segment of the antennae is longer, and the whole antennae narrower.

Aphis ficus, Theobald.

In two tubes of Aphids found on *Ficus sycomorus* were several in which the antennae of the apterae are of five segments only, the third being very long. These latter are probably "stem mothers" and were mixed up with typical *ficus* with the normal six-segmented antennae. Only one alate female occurred in the tubes, and this was normal in appearance, except that the third antennal segment has one less sensorium than in the type.

Macrosiphum compositae, Theobald.

Macrosiphum dahliafolii, Theobald, Bull. Ent. Res., vi, p. 106, fig. 1 (1915); op, cit. viii, p. 273, fig. 1 (1918).

Specimens from Italian Somaliland and Eritrea taken on cultivated *Carduus* show that there is much variation in the sensoriation of antennal segment iii, and I have in consequence sunk *dahliafolii* under *compositae*. In the original description of *compositae* the cauda of the apterous female was said to be one-quarter to one-fifth the length of the cornicles, but I find that the cauda of the type is apparently contracted, and in all other specimens since examined the cauda is as in *dahliafolii*, half to a little less than the length of the cornicles. The sensoria on antennal segment iii vary from 52 to 90 in the apterae and 80 to 100 in the alate females; in the apterae the sensoria do not reach so near the apex of the segment in some specimens as in others.

The food-plants at present known are Compositae, including *Carduus*, both wild and cultivated; *Chrysanthemum*, *Dracaena*, *Sparmannia africana* and a native plant called "mocatha."

The known localities are Nairobi, on Compositae (*Anderson*): Kampala, Uganda; on *Carduus*, 2.xii.1917; *Dracaena*, 2.xii.1917; *Chrysanthemum*, 2.x.1918; *Sparmannia africana*, 25. ix.1918 (*Gowdey*); Italian Somaliland and Eritrea, on cultivated *Carduus* (*Paoli*).

THE INCIDENCE OF A FUNGAL PARASITE OF SCALE-INSECTS IN NEW ZEALAND.

By J. G. Myers.

Aegerita webberi, Fawcett, is a very interesting parasitic fungus which has been recorded as attacking *Aleyrodes citri* in Florida, *Aleyrodes* and *Aspidiotus* in Ceylon, and an undetermined scale in New Zealand, and of which our knowledge has been recently summarised by Petch.* He notes that on the characters of the seal-brown sterile stromata it appeared probable that the forms from the three localities represented three species, but the sporodochia are identical in all, and they must therefore all be referred to *A. webberi*.

No trace of the host insect remains under the fully developed stroma.

The host relations of the New Zealand form, of which my material was kindly determined by Dr. G. H. Cunningham, Government Mycologist, are decidedly interesting. Petch's only New Zealand record was based upon examples attacking an unknown scale-insect on *Melicytus ramiflorus*, Forst. In my experience at Wellington (York Bay) and in North Auckland (Kawakawa) the host was always the large green endemic "Lecaniine," *Ctenochiton viridis*, Mask. In the two above localities the two chief host-plants of this scale—both heavily attacked—are *Nothopanax arboreum*, Forst. f., and *Hedycarya arborea*, Forst. These are both shrubs or small trees, the latter growing normally more in the shade than the former, which may sometimes occur even in certain heath formations near forest, as Cockayne has noticed. On these two hosts the scale is found, often in very great numbers, on the under surfaces of the leaves.

Curiously enough, while apparently every plant of *Nothopanax* and of *Hedycarya* in the beech forest at York Bay was attacked by *Ctenochiton*, usually heavily, the fungus, *Aegerita*, was never found by me on the *Nothopanax*, but only upon the *Hedycarya*. Frequently every scale on the plant was attacked, but on one tree (2.ii.1924), about 7 feet high, growing much in the shade of the beeches (*Nothofagus*), the upper leaves still showed a few half-grown and adult *Ctenochiton viridis*. The lower leaves, particularly those on branches springing from near the base, had the upper surfaces thickly encrusted with fumagine and the lower with very numerous *Ctenochiton*, of all sizes and all parasitised by *Aegerita* in various stages, but chiefly the final. The two lowest branches were quite dead, probably as a result of the scale attack.

One is tempted to suggest that the susceptibility to fungal attack of scales on *Hedycarya* is due to the shade and resulting humidity in which this host grows. This is supported by the greater percentage of parasitism on the lower branches.

The healthy scales excrete honey-dew extremely copiously, attracting—especially on *Nothopanax* in the sun—hordes of Diptera and Hymenoptera, including *Hystricia* and other Tachinids, *Syrphus*, and two species of *Salius*.

On *Nothopanax*, but to a much less extent on *Hedycarya*, the seat of each scale is marked by a prominent swelling upon the upper surface of the leaf, and in later stages by a yellowish colour. The scale thus lies in a shallow pit.

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* Trans. Brit. Mycol. Soc., xi, pp. 50–66, 1 pl., 1 fig., 1926.

THE BRITISH GALL MIDGES OF PEAS.

By H. F. Barnes, Ph.D.,

Entomological Department, Rothamsted Experimental Station.

There are in Britain three species of gall midges the larvae of which may be found in pea-pods : the pea midge (*Contarinia pisi*, Winn.), which is the most common and is sometimes a pest ; *Lestodiplosis pisi*, Barnes, a predator on the former ; and *Clinodiplosis pisicola*, sp. n., an inquiline. The larvae are readily distinguishable both by their colour and by the structure of their anal extremities (fig. 1).

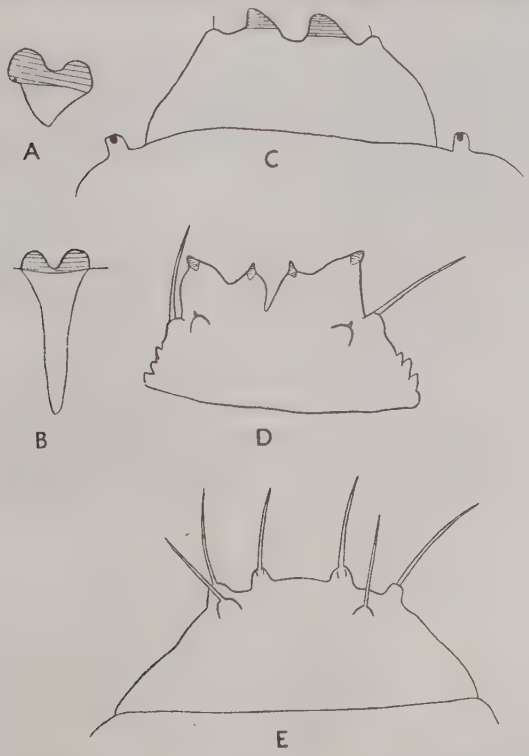

Fig. 1. Anchor process* : A, *Contarinia pisi*, Winn. ; B, *Clinodiplosis pisicola*, sp. n. Anal extremity : C, *C. pisi* ; D, *C. pisicola* ; E, *Lestodiplosis pisi*, Barnes.

The larvae of the pea midge (*Contarinia pisi*, Winn.) are well known and are probably familiar to all agricultural entomologists and growers of peas. The white larvae live inside the pods and feed on the "shuck." Recently the writer† has shown that besides attacking the pods, the larvae may live in the flowers and terminal shoots. Whether they attack the pods or flowers seems to depend on what stage the

* The figures of the anchor process of *C. pisi* and *C. pisicola* are not claimed to be of diagnostic value.

† J. Minist. Agric., xxxiv, pp. 159–161, 2 figs., 1927.

pea-plants have reached by the time the midges are on the wing; if the season is an early one, in all probability the flowers and shoots will escape attack, but in a late season the main attack will be concentrated upon the flowers and shoots, resulting in severe damage to the crop. In either case when the larvae are full grown they descend to the soil by bending themselves into the shape of a bow and suddenly releasing themselves. In the soil they pupate and may either develop into midges in about a month's time, or more often remain in the soil as larvae over winter and emerge as midges in the following spring. The adults are white to greyish yellow with clear wings. Soil fumigation with naphthalene seems to offer the best means of control.

The second midge whose larvae are known to live in pea-pods is *Lestodiplosis pisi*, Barnes. The larvae of this species are bright blood-red in colour with a well-developed head but no "anchor process" and are quite active in their movements. They are beneficial, as they feed on the larvae of the pea midge. Unfortunately this species is not very common and so far has only been found in Kent. Only one—or sometimes two—larvae are found in the same pod; usually they are found in pods that contain the white larvae of the pea midge, occasionally, however, none of these latter larvae is found to be present, as they have previously "jumped" to the ground. The adults of this midge have mottled wings, are reddish-orange in colour and have a typical black spot in the abdomen.

The third species is *Clinodiplosis pisicola*, sp. n., of which the technical description is appended below. The larvae are red in colour and sluggish in movement; their head is not so well developed as in the previous species, nor do they stretch out their heads so far. This is owing to the fact that they presumably feed on the sap inside the pods. In any case they are not beneficial nor definitely injurious. Captain J. R. W. Jenkins, Adviser in the mid-Wales area, very kindly sent specimens of the larvae from which adult midges have been reared. The larvae were found in ripe pods of Sweet Pea at Aberystwyth in late September, and very soon went to the ground. Under artificial conditions the midges emerged the following February and March. In colour they are greyish-orange to blood-orange and have slightly smoky to clear wings. This species has also been reared in late August and early September from larvae found by Mr. A. S. Buckhurst on peas at Harpenden, together with those of *C. pisi*, Winn., in late July and early August.

Fig. 2. *Clinodiplosis pisicola*, sp. n., dorsal view of male genitalia.

Clinodiplosis pisicola, sp. n.

Male. Length 2 mm. Antennae: 2+12, 1st and 2nd flagellar segments fused, stem of 3rd flagellar segment about 2½ times as long as broad, neck about 3½ times as long as broad, stem of 10th flagellar segment about 5 times as long as broad, neck about 6 times as long as broad, stem of 12th flagellar segment about 5½ times as

long as broad, terminal appendage about two-thirds as long as distal enlargement. Palps : 1st palp segment quadrate, 2nd twice as long as 1st, 3rd slightly longer than 2nd, distal segment about 3 times as long as 1st. Eyes contiguous. Thorax greyish lemon. Wings slightly smoky, 3rd vein reaching margin just beyond apex. Legs straw-coloured, femora with dark hairs, claws curved at right angles, on anterior and mid-legs bifid, on posterior legs simple, empodium much shorter than claws. Abdomen bright orange with dark bands dorsally and ventrally. Genitalia (fig. 2) : basal clasp segment with long setae and swollen on inner margin ; distal clasp segment glabrous ; dorsal plate bilobed with V-shaped emargination, each lobe cut away, on inside corner a short seta, on outside rounded edge several short setae ; ventral plate setose, distinctly longer than dorsal plate, extremity hollowed out ; style stout.

Type, Cecid. 1049 ; paratypes, Cecid. 1050, 1051, 1058, 1059, 1064, 1077, 1078, and 1079.

Female. Length 2½ mm. Antennae : 2+12, 1st and 2nd flagellar segments fused, neck of 3rd flagellar segment about 3–3½ times as long as broad, neck of 10th flagellar segment about 5 times as long as broad, elongation of 12th flagellar segment about ¼ length of enlargement, each flagellar segment with two rings of applied circumfila connected by longitudinal thread. Palps : 1st segment roughly quadrate, 2nd about 3 times as long as 1st, 3rd slightly longer, 4th about 4 times as long as 1st. Thorax greyish lemon, darker dorsally. Abdomen bright blood-orange. Ovipositor slightly extensile, with 2 oval oblong lamellae and a smaller one basally. Otherwise as in male.

Type, Cecid. 1069 ; paratypes, Cecid. 1060, 1067, 1070–1076 inclusive.

THE BIONOMICS OF THE BULB MITE, *RHIZOGLYPHUS ECHINOPUS*, FUMOUZE & ROBIN.

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(Plates VI–VIII.)

Introduction.

The Tyroglyphid mite, *Rhizoglyphus echinopus*, has long been associated with damage to the subterranean portions of a variety of cultivated plants. As long ago as 1885 numerous correspondents in the "Gardener's Chronicle" complained of the damage sustained by Eucharis bulbs, and in consequence the mite is frequently referred to in early literature as the Eucharis mite. Michael[4] deals very fully with the mite, and reference should be made to his work for a full description of all stages in its development. Michael further gives a good deal of information as to the life-history and habits, and notes that "*R. echinopus* is a most destructive creature which inflicts serious loss upon the gardener and even upon the agriculturalist—it attacks a large range of plants and it attacks them when they are in a living condition." Again, "It will undoubtedly eat decaying bulbs and will thrive fairly well on them —I have usually found that it prefers sound bulbs."

Since the appearance of Michael's monograph[4] repeated references to the mite have occurred in economic literature. Under the names of *R. echinopus*, *R. spinitarsus* and *R. hyacinthi*, the mite has been reported from nearly every portion of the world. The wide range of plants on which it has been found may be gathered from the following list, which is probably by no means an exhaustive one: Avocado seed, barley, beetroot, cassava, celery, clover, eucharis, garlic, hyacinth, iris, lilium, mango seed, narcissus, oat, onion, orchid, potato, tulip, vine and wheat.

In spite of the frequency with which reference to the mite has been made, there appear to have been few serious attempts to determine the true extent of the damage occasioned by it. There has, however, been of late years a growing tendency to discredit the observations of many of the earlier workers, who considered that the mite was a primary pest of considerable importance. Recent workers have rather considered it to be a follower of decay, caused primarily by some other organisms, or by unsuitable cultural conditions.

Welsford[6], in the course of work on narcissus diseases, states, "No case of bulb rot was obtained by deliberate infection by mite (*R. echinopus*)." Buckhurst (1), when making a number of deliberate infections of narcissus and hyacinth with the mite, obtained only one doubtful case of injury to hyacinth, although at the close of the experiment all controls, as well as the bulbs deliberately infected, were found to harbour numbers of the mites. The case of a hyacinth growing and flowering normally in a vessel swarming with the mite is also remarked upon. Subsequent experiments by the same writer[2] with quantities of hyacinths produced similar results. As opposed to the observations of the above workers, Ogilvie[5] states with reference to the mite, "Otherwise entirely healthy narcissus bulbs, growing amongst damaged ones, were found to be damaged by it, and it is attracted to decaying vegetable matter, such as bruised scales of lily bulbs—and subsequently enters the healthy tissues."

The present writer has been working on pests of the narcissus for a number of years. The work has necessitated a thorough survey of the existing literature concerning the subject and close contact with a large number of commercial growers, and has further included a laboratory examination of approximately five hundred

samples of narcissus bulbs from localities throughout the United Kingdom and from Holland. Each sample has consisted of from six to twenty individual bulbs.

It was found that *Rhizoglyphus echinopus* was present, in greater or lesser numbers, on something like 95 per cent. of the total number of bulbs examined. The literature quoted or referred to above clearly illustrates the diversity of opinion that has existed regarding the economic status of the mite. Enquiries amongst growers elicited similar contradictory opinions, and the desirability of obtaining exact data on the subject was indicated. Critical observation of the behaviour of the mite when living on narcissus bulbs, grown and stored under commercial conditions, was commenced in 1924, and during this and the three subsequent years numbers of experiments, to be described shortly, were carried out.

Description of the Mite.

An accurate and detailed description of the mite is given by Michael.[4] The work is well illustrated, and it is not necessary for our present purpose to repeat the scientific description.

The adult female mite (Plate VI, fig. 1) is roughly 1 mm. in length and 0·3 mm. in breadth, but may vary considerably. The male (Plate VI, fig. 2) is somewhat smaller. The body is globose, polished and translucent, yellowish-white in colour, frequently tinged with pink and giving a bluish-grey reflection. Legs and rostrum red to pink. The immature stages, with the exception of the hypopus, are very similar to the adults in appearance, but of a smaller size. Males of the genus *Rhizoglyphus* are interesting in that they are dimorphic, one form having the third pair of legs greatly thickened. No difference in behaviour has been observed in the two forms. The hypopus (Plate VII, fig. 2) is about 0·33 mm. in length and 0·2 mm. in breadth. The colour varies from light to dark brown, tinged with orange or pink. It is very highly polished, semi-transparent and covered by a large dorsal carapace. All stages of the mite are exceedingly sluggish in their movements.

Life-history.

The mites occur in considerable colonies on suitable food material (Plate VII, fig. 1), and as long as this is present and other conditions are favourable, reproduction takes place rapidly.

Owing to the normal occurrence of the mites in colonies and the impossibility of marking individuals with a view to subsequent identification, it is difficult accurately to determine the relative duration of the various stages. Attempts were, however, made to obtain information on this point by means of isolation of individual mites. Numbers were isolated from time to time in glass cells with plentiful food. Records of behaviour were kept and it was found possible to elucidate the life-cycle with considerable accuracy. At the same time, so much variation was found to occur that the limits of the duration of the various stages suggested by the observations are not likely to be extreme ones.

Every stage of the mite has been found to occur throughout the year. Eggs are laid singly, 13 being the largest number obtained from a single female. This number may be far short of the total laid by an unrestricted mite, for Yagi[7] records from 9 to 59 from observed females. The eggs were found to hatch from 8 to 15 days after being laid, the shorter period being observed in June and the longer in November. Hexapod larvae emerge from the eggs.

At a temperature of approximately 60° F. the larvae feed freely and in the presence of abundant food become inert after a period varying from 11 to 20 days. Ecdysis occurs after 3 to 5 days of inertion, and active nymphs emerge. After a further feeding period of 7 to 21 days the nymphs again become inert and remain so for 3 to 8 days.

Ecdysis again occurs and second stage nymphs emerge. These continue to feed for 8 to 23 days, become inert for 5 to 9 days, and then emerge as adults.

It may be seen from the above figures that a very wide variation occurs in the period occupied by the complete life-cycle, even when conditions are identical. The shortest period occupied from egg to adult, in the above observations, was 45 days and the longest no less than 108 days. The time limits suggested by these figures probably give a very fair representation of the time taken in metamophosis by individuals in an active colony. It was, however, noted during the observations that individuals frequently became inert, as if about to undergo ecdysis, remained so for periods extending into months and eventually again became active, without casting their skins. This device, which was also noted by Michael (4) in another Tyroglyphid, enables the life-cycle to extend to a very long period of time, and it seems probable that nymphs can persist in such a state in situations which have temporarily become unsuited to the needs of an active colony.

The Hypopal Nymph.

Thus far no reference has been made to the formation of hypopi, none having occurred in the series of breeding experiments referred to. Nevertheless, huge numbers of hypopi are known to appear from time to time, and attempts were made to account for such occurrences and to investigate this stage of the mite.

As a commencement, numbers of freshly formed hypopi were isolated on damp filter-paper and confined in glass cells at laboratory temperature. The isolations were made on 23rd March 1926. Observations were made at frequent intervals, and the majority of the hypopi remained healthy and unchanged until 16th June, when several underwent ecdysis and emerged as second stage nymphs. This observation confirms that made by Michael, except that the hypopal period persisted for much longer than in the cases recorded by him. The remaining hypopi transformed during the following four weeks. Numbers of the resulting nymphs were given food, and they rapidly transformed into adults. The remainder were kept in the original cells and all died, presumably from starvation, by 18th August.

A number of experiments were carried out in an attempt to determine the cause or causes contributing to the formation of the hypopi in a colony.

In June 1925 the effect of starvation on a number of vigorous colonies was investigated. Five such colonies were divided into two parts, and one half of each deprived of the bulk of its food supply. In every case the starved portions of the colonies produced numbers of hypopi, while the fed portions, with one exception, produced but few. In February 1927 an unsuccessful effort was made to repeat these experiments. No hypopi were formed, possibly owing to the low temperature, and the starved portions of the colonies had dwindled very appreciably after three months.

The effects of changed atmospheric humidity upon colonies of the mite were also investigated. In May 1925 three colonies were divided in halves, each portion having an approximately identical food supply. One half of each colony was slowly dried out, the corresponding halves being kept moistened. Examination after one week showed that reproduction was rapidly falling off in the drying colonies and continuing at a normal rate in the moistened ones. One week later a few hypopi were formed in each of the drying colonies and a like number in one of the moist ones. By the end of the third week one of the drying colonies had almost disappeared, a few nymphs and adults only being left. The remaining two contained a few hypopi and active adults, but the majority of larvae and nymphs appeared to be suffering from the effects of the drying. The moistened colonies were unchanged in appearance, but each had a few hypopi present. At the close of the fourth week the dry colonies were completely desiccated with the exception of a few hypopi in each. The damp colonies

were in a flourishing condition and each contained numerous hypopi. The experiment was then abandoned.

A repetition of this experiment was made in April 1926 with four colonies. A few hypopi were produced in all four desiccated colonies and in three of the moistened ones.

The foregoing experiments were admittedly too few in number to form a very valuable guide as to the factors influencing the production of hypopi. There was, however, a slight indication of somewhat increased production when conditions were rendered unfavourable to the maintenance of vigorous colonies, and it was at first concluded that this might actually be the case. It was also observed that vigorous colonies frequently produced enormous numbers of hypopi, especially during the summer months, and that one series of the above experiments, carried out in February, failed to produce any hypopi at all. Later observations and experiments point to temperature being the most important factor governing such production.

In March 1927, four colonies were divided as in previous experiments. One half of each colony was placed in a heated glasshouse and the remainder in a laboratory at a considerably lower temperature. Each portion was given an abundant supply of food and was kept in a moist atmosphere. Examination after a lapse of two weeks revealed the presence of numbers of hypopi in each colony under glass, while not one could be found in the laboratory. The experiment was immediately repeated with three further colonies and identical results were obtained. The seven colonies in the laboratory were kept under observation ; one of these commenced to produce hypopi early in May, and numbers occurred in each during the subsequent months.

It was further noted, during the four years 1924–27, that hypopi were always most abundant during the months May to September in all experimental stocks kept under anything approaching natural conditions, although they did occur in smaller numbers throughout the year. Nevertheless, it seems possible that, provided that a colony is able to maintain its vigour, slightly unfavourable conditions, excepting low temperature, may act as a stimulus to the formation of hypopi.

Considerable importance attaches to the obtaining of more definite information concerning the circumstances which give rise to the formation of hypopi. The hypopal stage of the mite is not a feeding and growing stage, but is rather a travelling stage. By means of it the mite is enabled to avoid extinction when conditions have become unfavourable for the maintenance of the more normal forms, and it has been shown that the hypopus of this particular mite can live for several months and at the close of that period transform again into an active, feeding nymph.

Narcissus Flies as Distributors of the Mite.

In the course of work upon the species of *Eumerus* attacking narcissus bulbs, it was frequently observed that specimens of these Syrphid flies bred or captured on the wing had numbers of hypopi attached to them (Plate VIII, fig. 2), and occasionally specimens of *Merodon equestris* were also found to be so encumbered. Examination of hypopi collected from such flies showed that the majority were identical with those bred from *R. echinopus* and undoubtedly belonged to that species. It can at once be seen that the flies act as distributing agents for the mites in the course of their journeys from bulb to bulb for the purpose of ovipositing. These flies attack both sound and previously diseased bulbs and occur wherever narcissi are grown in quantities. It is therefore clearly impossible to prevent the occurrence of such distribution.

Spread of Mites on Bulbs in Store.

It is almost essential for the mite to travel from bulb to bulb by means of the hypopus when the bulbs are in the ground, but no necessity for such an elaborate

process arises in the case of lifted bulbs. Commercial growers lift narcissus bulbs every few years for the purpose of increase. Quantities of bulbs are lifted and spread in close proximity on the surface of the soil, or preferably in a shed, in order to ripen. After a short period the bulbs are collected into heaps or sacked, until such time as they are to be re-planted. During this latter period, mites in all stages of development are at liberty to wander from bulb to bulb in search of suitable breeding grounds. Further, the time of lifting the bulbs coincides to a large extent with the period of the year during which hypopi, the most resistant stage of the mite, are abundant. In such circumstances these undoubtedly become freely distributed throughout such a collection of bulbs. Metamorphosis of these hypopi may be delayed until the bulbs are replanted, when humid conditions suitable for rapid breeding of the mites are re-established.

Natural Enemies.

An active, quick-moving mite, somewhat larger than *R. echinopus*, has very frequently been found in company with the latter. Examination showed that the mite belonged to the family GAMASIDAE, and it was subsequently identified as *Hypoaspis* sp. (Plate VI, fig. 3). It was not found possible to devote attention to the life-history of the mite, and it is not proposed to describe it here. The species appears to be common and generally distributed, at least in Devon and Cornwall, and when occurring with *R. echinopus*, is predatory upon the latter.

The *Hypoaspis* wander about on the colonies of bulb mites (Plate VIII, fig. 1), and at frequent intervals seize individuals, which they continue to carry about whilst sucking out the contents of their bodies, finally discarding the remains. It was found that half-grown nymphs and larvae were the stages usually selected for attack. Adult mites are rather large for the *Hypoaspis* to carry conveniently, but were sometimes attacked, particularly when smaller stages were not abundant. Although sometimes seized, hypopi were never observed to be killed, as they were discarded almost immediately.

That the *Hypoaspis* will attack organisms other than bulb mites is certain, as they are frequently to be found in localities where the mite does not occur. At the same time, the frequency with which they occur in company with the mites, the considerable voracity which they exhibit, and the facility with which they may be bred on an exclusive diet of *R. echinopus*, indicate that they are of considerable value in reducing the numbers of the latter species.

Experimental Work.

The life-history and mode of distribution of the mites having been elucidated to a very considerable extent, it is proposed to describe and remark upon a number of experiments. These were made in an attempt to infect healthy and previously diseased bulbs with the mites under varying conditions. The majority of the experiments were carried out with narcissus bulbs, but in a few cases onions and tulips were also employed.

Infection of growing Bulbs.

The experiments to be described under this heading consisted of attempts to induce injury to bulbs by infection with the mite. The infections were made while the bulbs were in a state of active growth in the soil, or alternatively, the bulbs were planted immediately after the infection had been effected.

A. Twelve healthy bulbs (Barri), growing in two pots were heavily infected with mites. 4.v.26.

Pots kept under bell jars to maintain a humid atmosphere. Mites breeding freely on decaying foliage and bell jars removed. 8.vi.26.

Bulbs dried *in situ*, in pots, removed from soil and examined. Offsets forming. Mites numerous and feeding in dried scales and on basal plates. Hypopi very numerous. Bulbs re-potted. 19.vii.26.

Bulbs left dry. Removed and examined. Fewer mites present in dead scales and basal plate. Re-potted and watered. 4.x.26.

Pots kept watered. Vigorous growth took place and excellent blooms were produced. One pot discarded, all bulbs being cut up and examined. Mites present in outer scales but no sign of attack on healthy tissues. 10.iii.27.

Remaining pot dried off and examined. Mites numerous but bulbs all in excellent condition. Control pots healthy throughout. Experiment abandoned 4.vi.27.

B. Six healthy bulbs (Soleil d'Or) heavily infected with mites congregated on damp filter paper. This was placed at roots and the bulbs potted under glass. 4.ix.26.

All bulbs showing foliage above soil. 10.x.26.

All bulbs grew vigorously and flowered by 15.ii.27.

Pots dried off and examined. Mites had riddled outer scales and were exceedingly numerous. The bulbs appeared quite healthy. 5.v.27.

Bulbs kept dry in laboratory. Mite still present between outer scales in vicinity of neck and basal plate. Bulbs cut up showed no attack on living tissues. Experiment abandoned 12.vii.27.

B, 1. Experiments conducted on similar lines to B.

B, 2. & B, 3. Results in each case identical.

C. Six healthy bulbs (White Lady) planted over numbers of mites as in B. 18.x.25.

One bulb removed for examination. Mites appeared to be penetrating neck and were damaging the roots very slightly. 21.xi.25.

Foliage a little blotched and distorted. Examined for *Tylenchus dipsaci*; no trace found. 2.ii.26.

Foliage looking vigorous, all bulbs flowered. 8.iv.26.

Bulbs removed from soil. Mites numerous, but no sign of injury to bulbs. Experiment abandoned 12.x.26.

C, 1. Experiment duplicated with 6 bulbs (Soleil d'Or). Bulbs remained healthy throughout. Experiment abandoned 5.x.26.

D. Nine healthy bulbs (Scilly White) were freed from mites and other organisms by immersion for 24 hours in a nicotine-soft soap solution and then thoroughly washed in running water. Each bulb was dried and gashed deeply with a knife, care being taken not to injure the growing point; six of the bulbs were infected with mites at the point of injury and all were planted. 15.iii.26.

Bulbs lifted and examined; 4 of the 6 infected ones found to be heavily infested in vicinity of wound. Remaining two healed, but some mites present. Controls healed. Bulbs re-planted. 10.iv.26.

Bulbs lifted and examined; 3 infected bulbs found to be completely destroyed and 1 partially so. Remaining 2 and controls growing well and would without doubt recover entirely. Experiment abandoned 5.vii.26.

D, 1. Experiment repeated with a different variety (Barri) in 1927.

Two infected bulbs died ; 3 formed small healthy bulbs around the undamaged growing points, all damaged scales being destroyed by the mites ; 1 recovered and grew away well, as did controls.

E. A number of bulbs (Golden Spur), lightly infected with bulb eelworm, were soaked in a nicotine solution, as previously, in order to free them from mites. Subsequent examination showed the eelworms to be unaffected. 10.i.26.

Twelve of the bulbs were infected with mites and planted ; 6 controls also planted. 18.i.26 .

All infected bulbs dead and swarming with mites ; 1 control, containing only eelworms, also dead, the remaining 5 being still alive. 4.v.26.

E, 1. The experiment was duplicated with a different variety (Soleil d'Or). Results very similar except that 2 controls and 2 infected bulbs grew away well and were found to be free from eelworms.

Infection of Bulbs kept out of the Soil.

These experiments were conducted with a view to obtaining information regarding the ability of the mite to damage stored bulbs. Whenever possible the bulbs were kept under conditions approximating to those in which stored bulbs are usually kept. With the exception of experiments L and L, 1, all bulbs used were especially selected as being perfect, no damaged or decayed areas being present on them.

F. Twelve small healthy bulbs (Ornatus) were subjected to mass infection by mites and kept in a large glass container on slightly damped filter paper. 18.vii.26.

One bulb found to be rotted by a fungus and swarming with mites. Remainder healthy, although covered with mites. 27.vii.26.

Outer scales and dried portions of basal plates still maintaining a considerable mite population. No sign of damage to interior of bulbs. 10.viii.26.

Mites all disappeared, owing presumably to the shortage of food and somewhat dry atmosphere. Bulbs healthy. 13.x.26.

G. Twelve healthy bulbs (Ornatus) were isolated on filter paper in separate glass cells and each infected with 3 gravid female mites. 27.vii.26.

Numerous mites present on bulb and paper in each cell. 19.viii.26.

Dead outer scales completely destroyed. Bulbs all healthy and mites disappeared, with the exception of a few hypopi in 2 cells. Experiment abandoned 15.x.26

H. A repetition of the above, with the exception that the bulbs were infected with 6 hypopi instead of adults. 27.vi.26.

Outer scales and dead portions of basal plates riddled with mites. 21.ix.26.

Fewer mites present. Bulbs still sound. 25.x.26.

Very few mites left. Bulbs still sound. Experiment abandoned. 11.xi.26.

J. A batch of bulbs (Emperor) were subjected to the hot water treatment, 3 hours at a temperature of 110° F., and left wet in a glass vessel. 2.iii.27.

Twelve of the bulbs were heavily infected with mites bred on onion. 5.iii.27.

A heavy mite infestation in the outer scales. 4.v.27.

All dead outer scales riddled and mites tunnelling dead portions of basal plates. 8.vi.27.

As previously, but many hypopi present. 16.vi.27.

One bulb dead and completely destroyed. A fungus present was probably responsible. Remainder healthy. 10.viii.27.

Eleven remaining bulbs still healthy and mites still numerous on exterior. Experiment abandoned. 18.x.27.

J, 1. A repetition of J, using mites from a different source. Commenced. 5.iii.27.

Position as in J. Two bulbs cut in half for examination and subsequently replaced with the rest. 8.vi.27.

Cut bulbs entirely destroyed. Remainder healthy and mites still numerous. 14.ix.27.

Bulbs which had been out of the ground for over 12 months still healthy. Mites becoming fewer. Experiment abandoned. 18.x.27.

K. Eight healthy onions were infected on the sides with mites placed in inverted glass tubes, held in place with vaseline. Care was taken not to wound or bruise the onions. 16.v.27.

Mites still *in situ*. No sign of injury. 19.vi.27.

Five onions attacked by a rapid decay, probably of bacterial origin. Mites immediately entered and the onions were completely destroyed. 19.vii.27.

Three remaining onions healthy, all mites dead. 15.ix.27.

K, 1. Experiment repeated with narcissus (Soleil d'Or). All mites died.

K, 2. Experiment repeated with narcissus (Barri). All mites died.

L. Nine bulbs (Cervanthes) lightly infected with bulb eelworm, were washed in a nicotine solution as in previous experiments. 23.iii.26.

Six bulbs each infected with 1 gravid female mite and placed in a separate container. 24.iii.26.

Enormous multiplication of mites on 5 bulbs. Infection failed on the 6th. 4.v.26.

Five bulbs entirely destroyed. The 6th resembled the controls which were still living and contained increasing numbers of eelworms. 16.vii.26.

L, 1. A similar experiment carried out in 1927. 12 bulbs (Soleil d'Or) were used.

All bulbs infected with eelworm plus mite were entirely destroyed within four months. The 12 control bulbs containing eelworm alone were all alive at the end of that period.

Infection of Bulbs in Store. Bulbs subsequently planted.

In practice, it may be assumed that bulbs frequently become infected by wandering mites while stored in quantities. Experiments were therefore made in order to determine whether bulbs infected in this manner would subsequently suffer from the presence of the mites.

M. Twelve small healthy bulbs (mixed varieties) were isolated in cells and infected with mites. 16.vi.26.

Mites working under dead outer scales. 27.vii.26.

Position as previously. 19.viii.26.

Root formation commenced. Bulbs planted in an insectary. 4.x.26.

All 12 bulbs threw vigorous and abundant foliage, but were too small to flower. 12.iv.27.

Bulbs examined. Mites still present but bulbs had increased in size and appeared perfectly sound. Experiment abandoned. 16.vi.27.

M, 1. Experiment duplicated. 16.vi.26.

Mites present on every bulb as in M. No sign of injury. Experiment abandoned 16.vi.27.

N. Twelve healthy tulip bulbs heavily infected with mites and placed in glass container. 27.vii.26.

Some attempt to pierce outer scales. Huge numbers of hypopi forming. 13.ix.26.

All bulbs apparently healthy. No sign of mites externally. One bulb cut and large numbers of hypopi found beneath scales. Bulbs planted. 13.x.26.

One bulb cut and numerous nymphs found. No sign of attack on living tissue. Some nymphs dead, presumably from starvation. 1.xi.26.

All bulbs removed from soil and cut open. No injury found. A few adults and immature stages congregated around root bases. Experiment abandoned. 10.iii.27.

N, 1. Experiment duplicated.

Result of examinations as in N until 1.xi.26.

No mites found at final examination. 10.iii.27.

O. Twelve healthy bulbs (Ornatus) were infected with immature mites. 27.vii.26.

Outer scales and dead portions of basal plates riddled by mites. 5.viii.26.

No increase in the number of mites present. 25.viii.26.

Mites still present. Bulbs apparently sound and were planted. 15.x.26.

All bulbs appeared normally and flowered well. Removed from soil and examined. Mites still present around base plates and beneath outer scales. No living tissues injured. Experiment abandoned. 15.v.27.

O, 1. Experiment duplicated, using different variety (Barri).

Result as before, with exception of one bulb. This was entirely destroyed. It failed to root and was apparently attacked by a ' basal rot ' fungus.

Infection of bulbs previously treated with hot water to free them from Bulb Eelworms, etc.

In view of the fact that hot water treatment is a universal practice wherever narcissus bulbs are grown in quantity, it was considered desirable to observe the result of mite infections on treated material which had previously contained bulb eelworms. It has already been seen that, in experiments J and J, 1, treated bulbs which had not contained eelworms were not damaged by mite infection.

P. Twenty-four apparently sound bulbs (Barri) were selected from a batch heavily attacked by bulb eelworm and narcissus flies in 1925. The bulbs had been subjected to hot water treatment in a commercial plant and subsequently carefully dried.

Twelve bulbs were infected with mite and all 24 planted. 12.x.25.

Seven infected plants and 12 controls showed foliage above ground. 9.xii.25.

Plants removed from soil and examined. Several control plants found to have become slightly infected with mites, but appeared healthy ; 8 of the originally infected bulbs sound ; 4 riddled with mites and entirely destroyed. 10.iii.26.

P, 1. Experiment repeated with different variety (Emperor). 12.x.25.
Twelve controls grew well, as did 10 mite infected plants. Two completely destroyed. 10.iii.26.

P, 2. A similar experiment with different variety (Ornatus) carried out in 1926.

Eleven control plants grew normally; one failed owing to fungal attack; 4 mite infected bulbs grew normally. Remaining 8 bulbs destroyed, with the exception that 10 small off-sets grew away from them and made good bulbs by the end of 1927.

It is only fair to state that the bulbs used in this last experiment were originally very severely damaged by long-standing eelworm infection.

Q. Twelve bulbs (Ornatus), from the same source as those used in experiment P, 2, were infected with mites and kept under observation in the laboratory. 19.xi.26.

Two bulbs cut and examined. Mites found to have entered dead tissues originally formed by the eelworms and to be breeding freely. 21.ii.27.

The bulbs unfortunately became a little dry; 2 more examined and found to be heavily infested with mites and containing some recently dead tissues. 4.v.27.

Four further bulbs cut; 1 completely dead and swarming with mites; 2 heavily infested as before and the remaining 1 almost free from mites. 13.vi.27.

Remaining bulbs became very dry; 9 controls were healthy and 3 dead at final examination. Experiment abandoned. 10.viii.27.

Summary of Experimental Results.

Infection of growing Bulbs.

Experiments A, B & C. Mites were found to persist on healthy undamaged bulbs for periods extending to 13 months without causing appreciable damage.

Experiments D & D, 1. Bulbs originally healthy and free from mites were artificially damaged. The majority of those infected with mites subsequent to being damaged were partly or wholly destroyed. Numbers of controls, similarly damaged, eventually recovered.

Experiments E & E, 1. Bulbs containing the eelworm, *Tylenchus dipsaci*, were in addition infected with mites. They were destroyed more rapidly than similar bulbs infected with the eelworms alone.

Infection of Bulbs kept out of the Soil.

Experiments F, G & H. Mites were maintained for three to five months on healthy bulbs. They destroyed the dead outer portions, but failed to maintain themselves, probably owing partly to unsuitable atmospheric conditions. They failed to damage living tissues.

Experiments J & J, 1. Bulbs previously subjected to hot water treatment were infected with mites. Colonies were able to flourish on such bulbs for seven months, and at the end of that time mites were still fairly numerous. The outer scales and basal plates were riddled, and bulbs cut for examination were subsequently entirely destroyed. In J, 1, the bulbs were out of the soil for more than twelve months and even then sustained no injury from the mites.

Experiments K. Mites were confined in actual contact with onions. They failed to effect damage, except on onions which became unsound, as the result probably of bacterial action. K, 1 and K, 2 were repetitions, using narcissi instead of onions. Mites failed to maintain themselves or to effect entry into the bulbs.

Experiments L & L, 1. Bulbs containing bulb eelworms were in addition infected with mites. The indication was that the mites considerably hastened the destruction of the bulbs.

Infection of Bulbs in Store. Bulbs subsequently planted.

Experiments M & M, 1. Healthy bulbs were infected with mites, kept under observation for four months and then planted. After a further eight months the bulbs were examined and found to be in excellent condition.

Experiments N & N, 1. These experiments were somewhat similar to the above, using tulip corms instead of narcissus bulbs. The corms were under observation for eight months and at the end of that period were in excellent condition.

Experiments O & O,1. Carried out on very similar lines to those above. After ten months of observation the mites still persisted and the bulbs were in excellent condition.

Infection of Bulbs treated with Hot Water.

Experiments P, P, 1 & P, 2. These were carried out with bulbs previously attacked by eelworms and bulb-fly larvae. Approximately one-third of the mite-infected bulbs failed, while only one control bulb in the whole series did so.

Experiment Q. Bulbs as in experiment P were infected with mites but were kept in the laboratory for observation. The experiment was not a very satisfactory one, but mites certainly entered and bred in numbers of the bulbs and appeared to hasten the death of several of them.

Discussion of Experiments.

A considerable number of experiments not included here were carried out. They were all on similar lines to the ones described, and no new facts or inferences emerged from them. In all experiments adequate controls were used, but numbers of these have been omitted from the descriptions, as their inclusion might tend to confuse the reader.

The infection experiments carried out with bulbs which were immediately planted were easy to effect satisfactorily. Some little difficulty was experienced with those necessitating the maintenance of bulbs in a comparatively dry condition for a number of months. In particular this was the case when individual bulbs had to be kept in small glass containers. A danger of suffocation occurred, or alternatively, too free a circulation of air, with the resultant desiccation of the mites, sometimes took place.

The mode of infecting the bulbs with the mites was varied slightly. In some experiments, mites were placed actually on the bulbs by means of a camel-hair brush. In others, portions of moistened filter paper, on which the mites had congregated, were placed in close proximity to, or in actual contact with, the bulbs to be infected. No difficulty was experienced in obtaining infections by either method and it was found that careful handling with a soft brush had no deleterious effect upon the mites.

The most striking feature of the experimental work was the total failure of every attempt to obtain damage to healthy bulbs. Mites were found to persist and to feed on the outer dead portions of growing bulbs for periods extending to thirteen months, the bulbs remaining entirely healthy during the whole of that time. This inability to effect injury remained even when bulbs had been kept out of the soil for abnormally long periods, and also when they had been subjected to hot water treatment prior to infection with the mite.

Mites confined in glass tubes actually upon healthy narcissus and onion bulbs were unable to gain entry to the bulbs, except in a limited number of cases where rapid decay of the onions set in. In these latter cases there were indications that the mites were in no way the originators of the decay.

Healthy bulbs infected under storage conditions and subsequently planted were likewise found to be entirely undamaged, although mites remained on them for as

long as ten months after the infections were made. It can therefore be confidently asserted that the mite is not able to attack healthy tissues and therefore is not a primary pest. At the same time mites can persist on the dead outer portions of bulbs indefinitely.

On the other hand, bulbs artificially damaged were readily attacked and in numerous cases entirely destroyed by the mites, while similarly damaged ones kept free from mites usually recovered. Bulbs already infected with bulb eelworm and narcissus fly larvae were found to be destroyed more rapidly when infected with mites also, both under storage conditions, and when growing. The mites obtained a hold on the dead and injured tissues inside the bulbs and so weakened the whole that rapid destruction was effected.

The experiments with bulbs treated with hot water were perhaps not so extensive as could have been desired. Healthy treated bulbs, subsequently infected with mites, were not damaged. Mite colonies persisted on the outer portions of the bulbs for a number of months, but no living tissues were attacked. Treated bulbs originally heavily infected with bulb eelworm and infected with mites subsequent to treatment were frequently destroyed, or severely damaged, in a similar manner to bulbs damaged artificially. The mites penetrated to the portions of the bulbs originally damaged by the eelworm and eventually so weakened the whole that destruction was effected. Notwithstanding the poor general condition of the bulbs used in these experiments, the majority of the uninfected controls eventually recovered. There is, therefore, no doubt as to the destruction of the infected ones having been directly caused by the mites. At the same time, there is every probability that less severely injured bulbs are able to withstand attack by the mites and eventually to produce good bulbs, even in the presence of very considerable numbers of mites.

The Practical Importance of the Mite.

It may be safely concluded that, provided that bulbs are in a healthy condition, there is, under normal conditions of culture and storage, no fear of their suffering directly from the presence of the mites. It has been shown that the hypopus is readily transferred from place to place by bulb-flies, and that spread from one bulb to another can be effected by the mite while bulbs are in store. Further, examination of bulb samples has shown that the mite is universally distributed. It is therefore not possible to keep bulbs entirely free from mites for any great length of time. It must be remembered, however, that the mites are probably capable of carrying spores of injurious fungi from bulb to bulb, and for this reason alone every effort should be made to keep their numbers as low as is reasonably possible.

There is no doubt that the mites can effect the destruction of bulbs originally damaged by mechanical means, or by some other organism, even when such bulbs would otherwise stand a very good chance of ultimate recovery. Mechanical injury is frequently occasioned when bulbs are being lifted, particularly when they are ploughed out, as is the practice in some growing areas. Care in lifting would in a large measure reduce such losses from mite injury. Bulbs containing eelworm or damaged by bulb-fly larvae make ideal breeding-grounds for the mites. It must be remembered that, apart from the undesirability of having such bulbs in the ground a moment longer than can be helped, the mites will assist materially in hastening their destruction.

It has been demonstrated that hot water treatment does not in itself render a bulb more liable to attack from the mites. At the same time, a bulb that has been treated in order to rid it of eelworm or bulb-fly must be considered as similar to one suffering from mechanical injury. If the injured portions of the bulb are extensive there is every probability of the mites eventually destroying the bulb. It can be seen, therefore, that the early diagnosis and treatment of eelworm attack is of the utmost

importance. In the event of the damage being slight the bulb will in all probability be sufficiently vigorous to make a good recovery almost immediately, but mites will be likely to effect its destruction if large areas are already decayed. Treatment for eelworm will effectually destroy all mites present in the bulbs, and it is plainly desirable that such bulbs should not be subjected to reinfection prior to re-planting, for infection will materially reduce the chances of recovery of the less vigorous. Portions of damaged and rotting bulbs should always be carefully collected and destroyed, since if left in or on the soil, mites will multiply in them and mass infection of bulbs planted in the vicinity will be likely to occur.

It may be said that so long as narcissus bulbs are subjected to healthy conditions the mite will cause no damage, provided always that disease-causing organisms are not present. As soon, however, as bulb eelworm, bulb-fly larvae or fungi effect injury, or the bulbs are damaged by careless cultural methods, mites will increase rapidly and ultimately hasten the destruction of the bulbs. Immediate steps should be taken to ascertain the cause or causes of injury whenever rotted bulbs are found. Delay in recognising and treating bulb diseases will enable the mites to obtain a firm hold in the damaged bulbs, and heavy losses may be anticipated.

Control Measures.

The importance of keeping a check on the numbers of the mites is clear, and attention to the following points will be found to do much towards maintaining such a check.

Lifting.—Bulbs should be lifted carefully. Badly cut ones should be discarded, as they will constitute breeding-grounds for the mites and will themselves in all probability fail to recover from attack.

Destruction of damaged and rotting bulbs.—Mass infection by mites of bulbs treated with hot water may cause extensive losses. Every cut or rotted portion of bulb left in or on the ground will constitute a breeding-ground for the mites. All such bulbs should therefore be collected and destroyed.

Storage.—Store bulbs under hygienic conditions and work over them periodically, picking out all soft ones. Fungous storage rots will produce suitable foci for mites to breed in extensively. Such mites in their subsequent journeys in search of further food supplies may well act as distributors of these diseases.

Hot water treatment of bulbs.—The hot water treatment of bulbs for the control of bulb eelworm and bulb-fly larvae is widely practised, and adequate descriptions of the process are easily obtainable. The treatment will also free the bulbs from mites. It must be remembered that treated bulbs are particularly prone to subsequent damage by mites. Every effort should therefore be made to avoid re-infection before the bulbs have made a good recovery from their previous injuries.

Early treatment of bulbs infested with eelworm.—Early diagnosis and treatment of bulbs infested with eelworm is essential, if considerable losses from mite infestations are to be avoided later. Bulbs which have large areas of decayed tissues present prior to treatment will subsequently fall easy victims to the mites.

Fumigation.—Fumigation of bulbs with para-dichlorbenzene will effectually destroy the mites. A method of fumigation has been briefly described by the writer [3] in reference to the control of the lesser bulb-flies, *Eumerus* spp., in narcissus bulbs. The dosage there advocated may be adhered to.

Summary.

The foregoing observations and experimental work clearly indicate that the bulb mite, *Rhizoglyphus echinopus*, is not a primary pest of the narcissus. At the same

time there is every indication that the mite does bring about the destruction of bulbs originally damaged by other organisms or by mechanical means, which would normally recover from their original injuries. Further, the mites can undoubtedly carry fungus spores from bulb to bulb. It is therefore very desirable that every effort should be made to reduce the mite population in bulb-growing areas to a minimum. This can be effected by careful attention to the points enumerated under the heading of control measures.

References.

(1) Buckhurst, A. S. Jl. Min. Agric., xxxii, no. 8, Nov. 1925, pp. 734–735.
(2) ——. Jl. Min. Agric., xxxiv, no. 1, April 1927, pp. 4–6, 1 pl.
(3) Hodson, W. E. H. Bull. Ent. Res., xvii, pt. 4, June 1927, p. 382.
(4) Michael, A. D. British Tyroglyphidae, ii, 1903, pp. 84–96, pls. xxx, xxxi.
(5) Ogilvie, L. Rept. Dept. Agric. for 1925, Bermuda, 1926, pp. 36–63.
(6) Welsford, E. J. Ann. App. Biol., iv, nos. 1 & 2, Sept. 1917, pp. 36–46.
(7) Yagi, N. Berichte Ohara Inst. landwirtschftl. Forschungen, i, no. 3, 1918, pp. 349–360, 8 figs., pl. i.

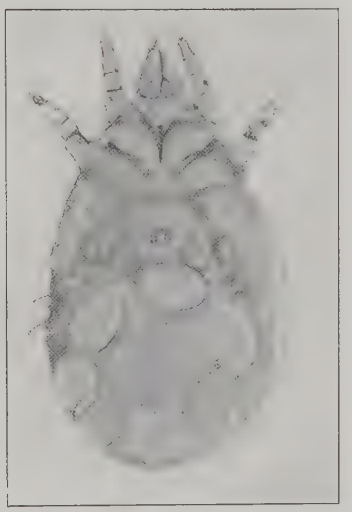

Fig. 1. *Rhizoglyphus echinopus*, adult female (× 100).

Fig. 2. *R. echinopus*, adult male (× 100).

Fig. 3. *Hypoaspis* sp., adult (× 50).

Fig. 1. A colony of *Rhizoglyphus echinopus* on a healthy narcissus bulb. (× 3).

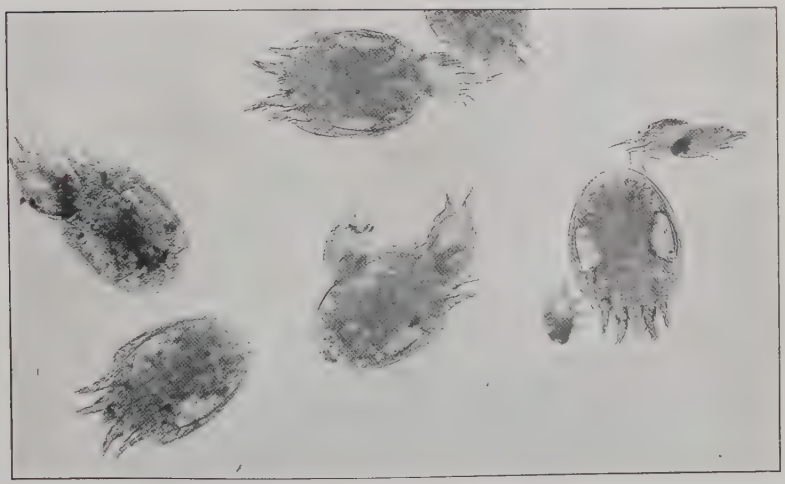

Fig. 2. *R. echinopus*; hypopi and larvæ. (× 75).

Fig. 1. *Hypoaspis sp.* preying on *Rhizoglyphus echinopus*. (× 7).

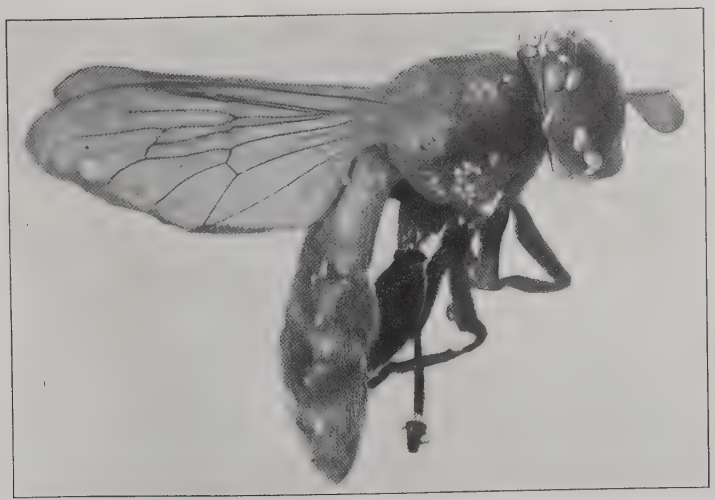

Fig. 2. *Eumerus tuberculatus*, ♀, carrying numerous hypopi. (× 14).

TWO NEW PARASITES OF *TIRATHABA RUFIVENA*, WALK., IN MALAYA.

By D. S. Wilkinson,
Senior Assistant, Imperial Bureau of Entomology.

As *Tirathaba rufivena*, Walk., is proving to be one of the important minor pests of coconuts in the Federated Malay States, some attention has recently been paid to the parasites of this Pyralid moth.

Nemeritis palmaris, sp. n.

♀♂. Black; scape (except for a thin dark longitudinal streak on the outside), mandibles (except the teeth), palpi, tegulae, front coxae distally, the four posterior coxae at their apices, all trochanters and trochantines, pale yellowish to red testaceous; femora, tibiae, tibial spurs, the four anterior tarsi, most sternites, 1st tergite at extreme apex, 2nd tergite in the distal half or third, in the ♀ all remaining tergites (except the basal third or fourth of the 3rd), in the ♂ the 4th and succeeding tergites (except for strong darkening above), and occasionally the 3rd tergite of the ♂ in the median third, red testaceous to red; hind tibiae towards apex, and hind tarsi, nigrescent.

♀♂. *Head*: flagellum with 35–39 joints, the first joint decidedly longer than the second, this latter equal to or just longer than the third; clypeus and face strongly reticulate-punctate, the facial orbits definitely more weakly sculptured; frons and vertex strongly coriaceous and also punctate. *Thorax* with the integument of the mesonotum and scutellum as in the frons; propodeon with normal areation, medianly with transverse carinae, laterally with strongly reticulate punctures. *Wings* with the areolet always present and long petiolate. *Legs*: hind coxae with the integument as in the frons; the longer hind tibial spur half, and the shorter spur a third, the length of the basal joint of the hind tarsus; claws pectinate, more strongly so in the ♀. *Abdomen*: the tergites minutely coriaceous except the basal half of the petiole; postpetiole with some very indefinite, scattered punctation; 2nd and 3rd tergites with rather more definite and more closely placed punctation; sheaths of ovipositor (or extension of ovipositor beyond apex of abdomen) about equal to the combined lengths of the 1st and 2nd tergites, this length about equal to the combined length of the hind tibia and the basal joint of the hind tarsus.

Length, 10 mm.

Malaya: Sepang, 5 ♀♀ (one the type), 7 ♂♂, and 4 specimens of unknown sex, 26.viii.1927, 29.ix.27, 4.xi.1927, 26.xi.1927, 21.i.1928, 4.iv.1928 (*G. H. Corbett*); Carey I., 1 ♀, 1.x.1923 (*G. H. Corbett* and *B. A. R. Gater*), 1 ♀, 4 ♂♂, iii.1923 (*G. H. Corbett*).

Type deposited in the British Museum.

Host. Bred from *T. rufivena*, Walk.

Only three species of *Nemeritis* have so far been described from the Oriental Region, namely *N. albovaria*, Tosq., *N. cana*, Tosq. (Mem. Soc. Ent. Belg., x, 1903, pp. 9–13), and *N. femorata*, Szép. (Notes Mus. Leiden, xxxii, 1910, p. 93); from these *N. palmaris* is very readily separable. *N. canescens*, Grav., however, is much closer, but is immediately distinguishable by its size, and by the colour of its four anterior coxae, which are entirely pale.

In previous publications *N. palmaris* has been identified either as an *Anilasta* or as a *Campoplex*; all such records must be taken as referring to the present species.

Apanteles tirathabae, sp.n.

♀♂. Black ; the four anterior legs (except their coxae and trochanters, which are black, and the middle femora, which are darkened in at least the basal half), and the basal half of the hind tibiae, red testaceous ; apical half of hind tibiae, and hind tarsi, nigrescent ; palpi and tibial spurs pale ; stigma and metacarp uniformly opaque dark brown ; costal veins more or less brownish testaceous ; remaining veins mostly brown or brownish.

♀♂. *Head* : face finely punctate (degree 1–2) ; facial depressions equidistant from the eye and apex of the clypeus ; posterior ocelli nearer to each other than to the eyes. *Thorax* : mesonotum separately punctate (degree 3–4), the punctures often rather shallow, more strongly punctate along the lines of the notauli, finely striate posteriorly except at extreme apex where it is unsculptured and polished ; disc of the scutellum polished, rarely though occasionally with extremely fine punctures (degree 1) ; propodeon shining, only indefinitely sculptured ; areola well marked, V-shaped at apex and often more or less closed at base ; costulae present though sometimes weak. *Wings* : the length of the transverse cubital half the breadth of the stigma, equal to the apical portion of the 1st abscissa of the cubital, shorter than the recurrent, longer than the pigmented portion of the 2nd abscissa of the cubital, just longer than half the 1st abscissa of the radial ; stigma shorter than metacarp. *Legs* : hind coxae basally above definitely punctate ; the longer hind tibial spur about four-sevenths, and the shorter spur rather more than a third, the length of the basal joint of the hind tarsus. *Abdomen* : the 1st tergite in ♀ more or less parallel-sided for about the basal two-thirds (possibly widening somewhat), thence definitely and sharply narrowed to apex, median length about three times apical breadth and about 1·66 times extreme breadth, basally smooth and polished, medianly with a strong, lightly rugose and punctate tumescence, immediately beyond which the tergite is faintly excavate medianly, in apical third shining, and more or less completely unsculptured ; in ♂ gradually and regularly narrowing from the base for two-thirds its length, then more quickly narrowing to apex, median length about 2·5 times apical breadth and rather more than 1·5 times extreme (basal) breadth, with the tumescence more strongly rugose and more coarsely punctate than in ♀ ; 2nd suture hardly apparent ; 2nd tergite unsculptured, with smooth, well-marked, straight, lateral sulci, in ♀ with the apical breadth 3·25 times the median length and 1·86 times the basal breadth, this latter about 1·4 times the apical breadth of the 1st tergite, in ♂ with the apical breadth 2·75 times the median length and 2·2 times the basal breadth, this latter equalling the apical breadth of the 1st tergite ; ovipositor sheaths as long as the hind tarsus.

Length, 3 mm.

MALAYA : Sepang, 2 ♀♀, 2 ♂♂, 12.iii.1928, 1 ♀, 1 ♂, 18.iv.1928 (*G. H. Corbett*).

Type deposited in the British Museum.

Host. Recorded as *probably* parasitic on *T. rufivena.*

This species runs to *A. platyedrae,* Wilkn., and *A. hasorae,* Wilkn., in my key to the Indo-Australian species of *Apanteles* (Bull. Ent. Res., xix, pt. 2), from which in the females it may be immediately separated by the sharply narrowed apical third of the 1st tergite.

AN ERIOPHYID MITE ON APPLE.

By A. M. Massee,
East Malling Research Station.

During 1926 and subsequently in 1927 the writer's attention was called to the presence of a mite infesting apples in newly planted orchards around East Malling, Kent.

In the first instance this species of mite was found in considerable numbers on the foliage of wild crab apples growing in the vicinity of Sevenoaks, Kent, and later in the New Forest District, in the summer of 1925.

This mite has since proved to be very common on the cultivated apple—Hormead Pearmain—during the summer of 1926, and considerable damage was caused to the foliage of that variety as the result of its attacks. Similar damage was noticed in 1927.

Specimens of this acarus were obtained and examined microscopically, and the mite was found to belong to the subfamily Phyllocoptinae, and is included in the genus *Phyllocoptes*. The species is *Phyllocoptes schlechtendali*, Nal.

In cases of a severe attack the mite causes considerable damage to the foliage of the apple, the leaves frequently drying up prematurely. The fruit is attacked also in some cases. The mite punctures the epidermis and thus causes slightly pitted and speckled fruit.

It is considered that this mite is generally distributed throughout England. However, it is not noticed unless it becomes abnormally common, since it lives on the lower surface of the leaves amongst the fine hairs.

When present in small numbers only, the puncturing and feeding of the acari causes the leaves to become somewhat faded, and frequently of a silvery appearance as well.

Isolated specimens of this mite have been found on pear trees.

It has not been possible to follow out the life-cycle in detail, but a few observations are worthy of note. The mites hibernate under the bud-scales and under loose bark. They do not hibernate in large colonies, but sometimes five or six individuals may be seen under one bud-scale. The mites become active as soon as the buds commence to open. Their eggs have been detected on the lower surface of apple leaves (Hormead Pearmain), but it is not known when egg-laying commences.

This mite was recorded first from Central Europe by Nalepa in 1890, and it was described and named by him at that date. It is recorded also from America and appears to be a pest of some economic importance in that country.

The mite is fully described below, together with references, host-plants, etc.

Phyllocoptes schlechtendali, Nalepa.

Phyllocoptes schlechtendali, Nalepa, Anz. Ak. Wien., xxvii, 1890, p. 2.; Nalepa, SB. Ak. Wien, xcix, 1890, p. 62, pl. iv, figs. 3, 4.

Body large, acuminate, broadest at posterior margin of thoracic shield. Shield 50 μ broad, 44 μ long, almost semicircular, anterior edge projecting forward, strongly curved and completely covering rostrum, lateral edges very slightly projecting. Thoracic shield marked with six longitudinal furrows, two of which pass through central portion of shield, converging towards apical margin. Sides of shield smooth. Thoracic bristles situated at posterior margin, widely separated (24 μ apart), directed towards apical lobe. Bristles 34 μ long, stout, acuminate. Warts of thoracic bristles conspicuous.

Rostrum short, 18 μ long, strong, markedly curved towards apex. First pair of legs 42 μ long, 4th and 5th joints 12 μ, tarsal bristles 18 μ, claws 8 μ. Second pair of legs 38 μ long, 4th and 5th joints 10 μ; bristles strong; feathered claw 4-rayed, 4 μ long, delicate.

Sternal ledge simple. First and second pair of coxal bristles short and inconspicuous; the 3rd, 22 μ long, stout, conspicuous.

Abdomen with smooth tergites, the number of which varies, there being generally 30, less frequently 28. The ventrites numerous, very narrow, fine, and smooth.

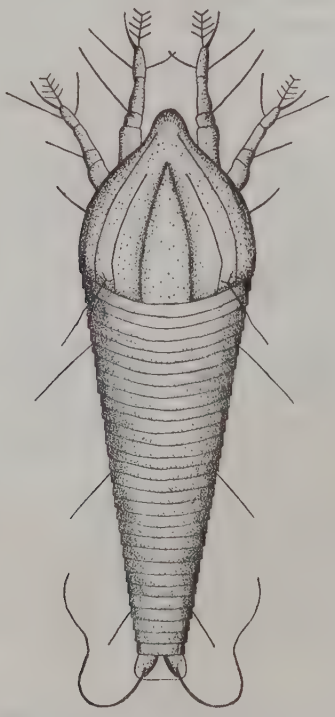

Fig. 1. *Phyllocoptes schlechtendali*, Nal. (x 470).

Lateral bristles 26 μ long, slender, situated below epigynium; 1st pair of ventral bristles 40 μ, 2nd pair 18 μ, 3rd pair 20 μ, tapering hair-like towards apex. Anal lobe small, conspicuous. Caudal bristles of medium length; accessory bristles absent. Epigynium flat, 25 μ broad. Coverflap smooth. Genital bristles placed near lateral edges, directed towards anal lobe, 26 μ long.

♀, 175 μ long, 50 μ broad; ♂, 140 μ long, 45 μ broad. Some individuals are 210 μ in length.

Host-plants: *Pirus malus*, L., *Pirus communis*, L.

Free-living on lower surfaces of leaves. Attacks frequently cause leaves to fade and become bleached.

Distribution: Sevenoaks, East Malling, and various localities in Sussex.

FURTHER OBSERVATIONS ON *BEESONIA DIPTEROCARPI*, GREEN.

By E. Ernest Green, F.E.S., F.Z.S.

Though our knowledge of this remarkable insect remains far from complete, fresh material, procured through Dr. C. F. C. Beeson, has enabled me to throw more light on its envelopment and to correct some misinterpretations in my earlier article (Bull. Ent. Res., xvii, p. 55, July 1926).

After careful study of this new material it becomes evident that the form described as " female of 3rd stage " (*loc. cit.*, p. 58) actually represents the third stage of the male series.

Differentiation of the sexes becomes apparent in the second stage, when—in the female series—the frontal area is enormously extended to accommodate the body of the 3rd stage female (fig. 2, *b*), while the post-frontal area, carrying the limbs and other organs, remains of its original size and assumes the form of a slender caudal appendage. This condition foreshadows the relegation of all the essential organs to the posterior extremity, so noticeable in the subsequent stages of the female series.

The second stage, in both male and female series, has been studied from exuviae only, which have, however, provided all essential characters.

The accompanying figures illustrate the new facts gained since the publication of my earlier article.

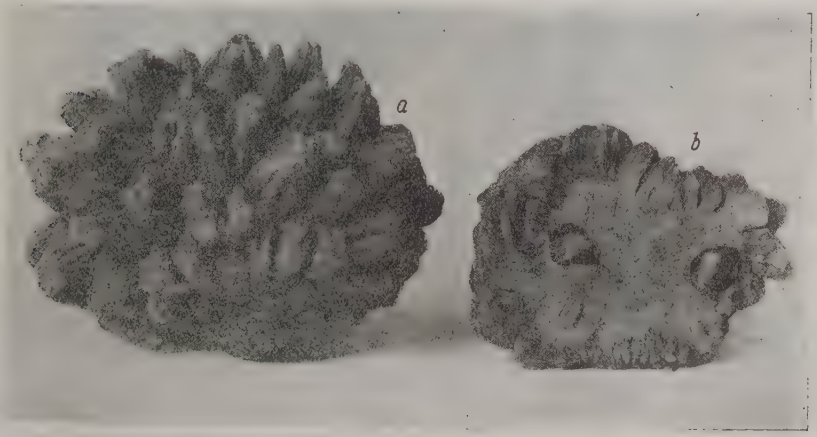

Fig. 1. *Beesonia dipterocarpi*: *a*, complete gall; *b*, section of gall, with insects *in situ*. Normal size.

Fig. 1, *a*, shows a full-sized photograph of one of the large foliaceous galls. These appear to develop at the extremities of the smaller branches of the tree and to result from a conglomeration of hypertrophied leaf-buds. As shown in a section of the gall (1, *b*), the insects occupy separate cavities in the woody core. A medium-sized gall may contain as many as a dozen fully developed females. Each insect rests with its posterior extremity directed outwards, usually in close connection with a crevice leading to the surface. The opposite extremity appears to be attached to the lining tissue of the cavity. Very old individuals may have the whole surface

rigid and densely chitinised, but the anterior half of the body is usually colourless and membranous. In the crevices of the galls are crowded great numbers of the earlier stages of the male insects.

At fig. 2, *a*, is seen the exuviae of the 2nd stage female, with its frontal area enormously distended and containing the globular body of the early nymphal stage (2, *b*). In this condition the composite insect has much the appearance of a balloon, the ' basket ' being represented by the attenuated body of the larva, carrying the antennae and limbs. The antennae of the 2nd stage larva (2, *d*) are 3-jointed, the third joint taking the form of a stout, rugose club. The legs (2, *e*) are characterised by a stout femur and trochanter ; a very short tibia and an elongate tarsus, which is more than four times as long as the tibia ; the claw long and slender, inwardly curved. The posterior extremity (2, *c*) exhibits six short, truncate, cylindrical setae, arranged in a circle round the anal orifice, each with a small circular cell on each side of its base.

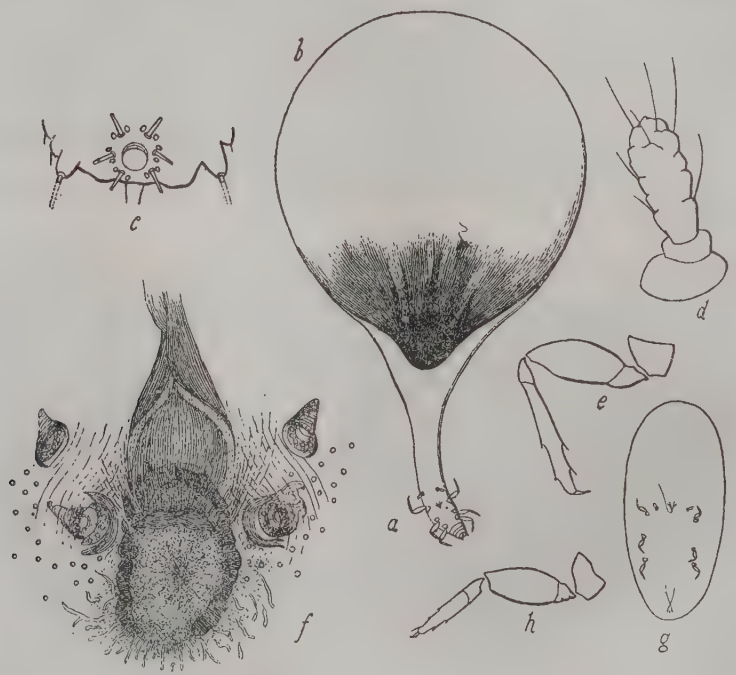

Fig. 2. *Beesonia dipterocarpi* : *a*, exuviae of 2nd stage female, x30 ; *b*, 3rd stage female occupying the extended frontal area of 2nd stage, x30 ; *c*, posterior extremity of 2nd stage female, x450 ; *d*, antenna of 2nd stage female, x450 ; *e*, 3rd leg of 2nd stage female, x220 ; *f*, posterior area of 3rd stage female, x130 ; *g*, exuviae of 2nd stage male, x30 ; *h*, 3rd leg of 2nd stage male, x220.

The 3rd stage female, or early nymph (2, *b*) may be either globular or ovate, the length—in some examples—equalling twice the breadth. The hinder extremity is always densely chitinous, but the position and structure of the four spiracles, which are clustered in close proximity to the anal orifice, are clearly distinguishable. Each spiracle has a ring of conspicuous pores within the atrium (2, *f*). The anal orifice is still encircled by short cylindrical setae. Shortly anterior to the anal orifice is an obscure funnel-shaped organ, without external aperture, which I suppose to be a

rudiment of the future oviduct. Mouth-parts, consisting of a rudimentary tentorium, with accompanying rostral filaments, are noticeable in this stage of the insect : but these organs appear to be floating freely within the body cavity, without any dermal attachment.

There appears to be a 4th (later nymphal) stage, superficially resembling the 3rd but differing in the enlargement of one pair of the spiracles, which is now fully double the size of the second pair (3, *b*). An example of this stage was found with the developing body of the adult female within it (3, *a*).

This partly developed adult is, as yet, but lightly chitinised, and the organs are but sketchily indicated. The posterior extremity (3, *c*) is deeply invaginated and folded in a manner that is difficult to interpret. The larger spiracles, the position of which is faintly indicated, appear to occupy a pair of large sacs situated one on each side of the central invagination. No definite anal ring (or setae) can be distinguished ; but, at the fundus of the invagination, is a foliate chitinous plate which may be a rudiment of the anal ring. The derm of the posterior parts is studded with what, at first sight, have the appearance of small papillae, but which—on closer examination—prove to be shallow pits, each of which shelters a quinquelocular pore (3, *d*).

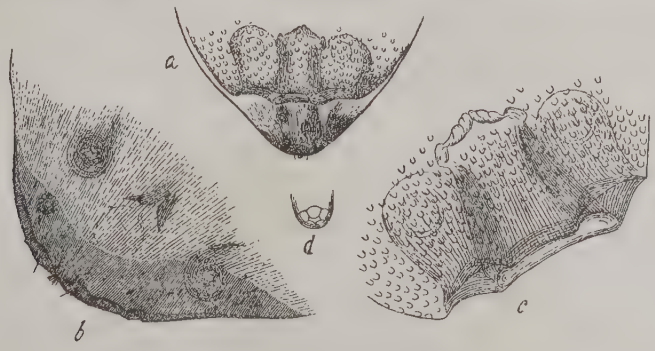

Fig. 3. *Beesonia dipterocarpi* : *a*, Posterior extremity of nymph, enclosing the developing adult, x30 ; *b*, posterior extremity of nymph, x80 ; *c*, posterior extremity of developing adult, x80 ; *d*, a single pore, x450.

In the male series, the 2nd stage has been observed only as exuviae (2, *g*), in which the frontal area is seen to occupy approximately half the extent of the whole insect. The antennae and anal ring are similar to those of the female of the same stage (2, *c*, *d*) ; but the limbs (2, *h*) show a marked difference, being relatively and actually smaller than those of the female, with the tarsus only three times the length of the tibia, and with the claw shorter and outwardly recurved.

The next (3rd) stage in the male series is that erroneously represented, on page 58 of the earlier article, as belonging to the female series. The intervening stages (probably two) between this and the adult male are still unknown.

PSEUDOCOCCUS GAHANI, GREEN, IN SOUTH AFRICA.

By C. J. Joubert, M.Sc. (Agric.),

Government Entomologist, Tomango, Nelspruit, South Africa.

Until the end of 1926 it was not known that *Pseudococcus gahani*, Green, occurred in South Africa. That it had not been recognised before is perhaps due mainly to the fact that very frequently it is found in association with *P. maritimus*, Erhorn, and was thus regarded as a form of the latter species. It may be noted here that *P. capensis*, Brain (Ann. Ent. Soc. Amer., v, p. 182, 1912) is a synonym of *P. maritimus*, Erhorn, as previously recorded in " Farming in South Africa " (i, pt. 2, p. 64, May 1926).

In October 1926, some mealybug material in alcohol was sent to Prof. G. F. Ferris, Stanford University, California. The material was collected from pear trees at Elsenburg, Cape, and contained what the writer considered at the time to be pink and slate-grey forms of *P. maritimus*.

Prof. Ferris, who is an authority on the Pseudococcinae, was kind enough to examine the material, and the following is a quotation from his letter, indicating plainly that we have one more name to add to the list of mealybugs to be found in the Union.

> " Your alcoholic material contained some specimens of *Ps. maritimus*, but it also contained *Ps. gahani* Green. The latter is a species which was described by Green from England, and a little later as *Ps. citrophilus* Clausen, from California. Here it is our worst mealybug. It is an extremely serious pest on citrus and occurs on almost every other kind of flowering plant. It is certainly not a native here, nor is there any reason to think that it is native in England. In life this is distinguishable from *maritimus* by the fact that it has a double row of dark spots down the dorsum and by the fact— utilised by field inspectors—that the fluid which is thrown out from the dorsal osticles when the insect is disturbed is wine-coloured and not yellow. On the slide it can readily be recognized by the fact that the pores about the anal lobe cerarii are not concentrated into a circular mass and by the fact that normally both anal lobe and penultimate cerarii are surrounded by a chitinised area."

It may be recorded also that a further noticeable difference is that when boiled in a weak solution of potash (about 8 per cent.) *P. maritimus* imparts a salmon pink and *P. gahani* a bluish colour to the liquid. *P. gahani* has not yet been reported from citrus in South Africa, and the writer wishes to make an urgent appeal to South African workers who find suspicious-looking mealybugs on citrus, to forward at least a dozen specimens for determination to the author, or to the Chief Entomologist, Box 513, Pretoria.

It is not deemed likely that the distribution of *P. gahani* at the present time is any wider than that of *P. maritimus*, namely, the Cape Peninsula, Somerset, Stellenbosch, Paarl, Wellington, Ceres, Tulbagh, Worcester, and possibly Robertson and Montagu. It would be almost impossible to ascertain the date of the importation of this pest into the Union.

An attempt was made to find if in the case of *P. maritimus* and *P. gahani* the females of the one species could be fertilised by the males of the other, a possibility that is suggested by the close relationship in which these two species are found to live in so many cases in this country. However, no definite results were obtained up to August 1927, when the writer was transferred to the Transvaal and had to abandon this particular line of work.

SURRA IN MAURITIUS AND ITS PRINCIPAL VECTOR, *STOMOXYS NIGRA*.

By A. Moutia,

Scientific Assistant, Entomological Division, Department of Agriculture, Mauritius.

Part I.

Trypanosoma evansi, the pathogenic agent of surra, is a flagellate measuring 33μ in length, and 1·5-1·7μ in breadth, without including the undulating membrane. It has an elongated body and a very conspicuous flagellum. This protozoan is very mobile and can easily be recognised when examined in a wet film under low power. It is sometimes present and sometimes absent in the circulation of a diseased animal. Its presence always coincides with an increase in temperature. This explains the intermittent or remittent nature of the fever, characteristic of surra-infected animals.

Many mammals are affected by *Trypanosoma evansi* : *e.g.*, horses, mules, asses, oxen, camels, dogs, deer, rabbits and guineapigs. In equines the disease is fatal, even with specific treatment, within a period of one or two months, the death-rate being 100 per cent. Bovines are more resistant to the disease, and the death-rate without treatment amounts to 25 or 30 per cent. According to Laveran, in the majority of cases death in bovines is due to anaemia rather than to the disease itself. It is recorded that diseased bovines can resist for long periods without any treatment other than complete rest and adequate feeding.

The first outbreak of the disease in Mauritius was recorded in September 1901, in a consignment of cattle from India. Soon after this importation, animals began to die in large numbers ; the cause of this epizootic remained obscure until March 1902, when Dr. Aime Lesur diagnosed it as surra. The scourge spread rapidly among equines and cattle throughout the Island, no treatment whatever being then known for the disease. The epizootic was a severe blow to planters, since at that time mechanical traction was practically non-existent on sugar estates. It is recorded that from July to October 1902, 1,882 equines and 1,681 cattle died. To cope with the situation thus created, a sum of Rs. 6,000,000 was raised as a loan by the Colonial Government, the proceeds of which were expended on installing tramways on estates to replace animal transport.

No sharp and distinctive symptoms are present in a surra-infected animal — particularly bovines; and fat and healthy-looking animals may be found working whilst their temperature is high and trypanosomes are actually present in their peripheral blood. In acute cases the apparent symptoms are : high intermittent fever, temperature above 104° F., emaciation, oedematous swelling of limbs, great muscular weakness, skin and hair harsh, and paralysis, culminating in death.

The only differential diagnosis is the examination of blood-smears for the presence of trypanosomes ; the latter being sometimes rare in the circulation, inoculation tests with other sensitive animals, such as dogs and guineapigs, are also necessary.

Surra is now endemic throughout the Island. It exists all the year round, but is more prevalent from October to March, which is the period of most intensive work for animals and coincides with the summer occurrence of biting flies.

It is reported that sheep and goats may act as hosts of *Trypanosoma evansi*, which has no pathogenic effect on them, and these animals may in consequence serve as reservoirs of the virus.

It has long been believed that surra can be transmitted mechanically by biting flies, and several authors have succeeded in transferring surra from one animal to another by the help of Tabanids, *Stomoxys*, ticks and fleas. As will be shown later in this report, the only possible vector in Mauritius is *Stomoxys nigra*.

It has been ascertained after numerous experiments that soamin injection combined with subsequent absorption of arsenious acid is the best treatment for this disease in cattle; other animals, although they may show long periods of amelioration, nevertheless finally succumb.

The chief prophylactic measures that have been adopted for the control of surra are: (1) The prohibition of the importation of animals from countries where the disease exists; (2) the inauguration of a systematic campaign for detecting diseased animals; and (3) measures for the destruction of biting flies.

In relation to the second of these measures, the campaign has been devised by the Department of Agriculture and consists in the systematic survey of all equines and bovines of the Island by Stock Inspectors working under the Government Veterinary Surgeon. These Stock Inspectors go round the Island and take smears of blood from animals. The smears are sent to the Head Office, where they are examined. All bovines found to be suffering from the disease are placed under quarantine in their respective stables, and the owners are notified that treatment must be carried out within 48 hours; if this notice is not complied with, slaughtering is ordered. Facilities for treatment are provided all over the Island by means of Dispensers at Government Dispensaries and Estate Hospitals, who have been trained in the technique of treatment by the Government Veterinary Surgeon. When treatment is over, the blood of the animal is examined by the Government Veterinary Surgeon, and if found free from trypanosomes, the animals are liberated from quarantine.

When cases of surra are detected in equines, no treatment is allowed, immediate slaughtering of the animal being enforced.

This campaign was started during the year 1923, and results are as follows :—

Year.	Number of slides examined.	Number of cases of surra detected.	Percentage of infected animals in total examined.
1923	5,968	150	2·5
1924	5,959	37	0·5
1925	7,330	59	0·8
1926	7,506	44	0·6
1927	13,488	72	0·5

When surra is detected in a herd of bovines, treatment is applied to the whole herd without any exception; but as some individuals, after the treatment is over, may still harbour the parasite and thus act as reservoirs for reinfection, some owners, with a view to sterilising such carriers, repeat the treatment every year.

The definite proof of the transmission of surra by *Stomoxys nigra* is hereafter discussed. It ensues therefrom that the destruction of this biting fly is of importance. Conditions in Mauritius hardly permit of compulsory sanitary regulations respecting the breeding of flies, especially on sugar estates where manure is as a rule prepared for the needs of the staple industry. However, destruction of the adult flies by means of fly-traps is now being resorted to on a large scale.

Repellent substances are frequently used on animals, particularly those at work, with a view to keeping off biting flies. That which has given the best results is a mixture composed of 4 litres fish oil, 50 cc. tar, and 500 cc. petrol. The back and legs of the animals are coated with the mixture.

Occurrence of *Stomoxys nigra* in Mauritius.

The entomological fauna of Mauritius is poor in blood-sucking flies. In various parts of the Island and at different times of the year, collections of flies were made,

and the only biting fly commonly observed was *Stomoxys nigra* ; and recently out of 2,000 insects captured by means of a fly-trap, this fly constituted 99 per cent. of the total. There is therefore little doubt on presumptive grounds that this is the principal, if not the only, vector of surra in Mauritius, especially as a closely related species, *Stomoxys calcitrans*, has been proved to be a vector of surra in other countries.

Nevertheless, although the presumptive evidence was very strong, actual proof by transmission had not hitherto been obtained. The present study was therefore undertaken in order to elucidate this point and also with a view to ascertaining whether development of the trypanosome took place in the fly.

Life-history of the Fly.

The female lays its eggs singly or in clumps, usually on bovine excreta in the field, and rarely on manure piles, the number laid by one female varying from 60 to 125. The egg is of a creamy white colour and 1–2 mm. in length. When laid on cattle droppings, the eggs hatch in 2 to 3 days. The young larvae measure 3–4 mm. in length and reach maturity within 14 to 18 days, when they measure 8–11 mm. Pupation usually takes place in the ground under the medium in which the larvae have been living, and pupae are most generally met with under the pads of cow-dung found in pastures. The pupal period lasts from 11 to 14 days, at a temperature of 25 to 30° C.

Before starting transmission experiments with this fly, it was of importance to know the number of days during which gorged flies could remain without feeding. Consequently a series of experiments was carried out in which flies in tubes were gorged with full meals of blood and then kept under observation without further feeding until they died. The following table summarises the results.

Number of Living Flies in Five Tubes.

1st day ...	4	2	3	5	5
2nd ,, ...	4	2	2	5	4
3rd ,, ...	4	2	2	4	4
4th ,, ...	1	1	1	4	3
5th ,, ...	0	0	0	0	0

From the above it ensues that these flies can, after a full meal, remain alive without further feeding for 3 to 4 days.

It was also necessary to ascertain the number of days they could be kept in tubes (6 in. by 1 in.) while being fed once or twice a day. The table shows that *Stomoxys* can be kept alive in captivity in tubes on two meals a day for as long as 8 days, with an average of 5 days.

Number of Living Flies in Nine Tubes.

1st day	3	5	6	3	7	6	3	10	7
2nd ,, ...	3	3	4	2	7	6	3	10	6
3rd ,, ...	3	2	2	0	3	3	3	6	4
4th ,, ...	3	2	2	—	0	0	3	4	4
5th ,, ...	2	2	2	—	—	—	2	4	3
6th ,, ...	1	2	1	—	—	—	2	4	1
7th ,, ...	0	0	0	—	—	—	2	4	1
8th ,, ...	—	—	—	—	—	—	2	4	1
9th ,, ...	—	—	—	—	—	—	0	3	0
10th ,, ...	—	—	—	—	—	—	—	0	—

In tubes 1 to 4 the experiments were conducted in April, and the remainder in October.

In order to provide living material for these experiments, gravid females were captured and allowed to lay in test-tubes. The young larvae obtained were fed on

cow-dung kept moist, while the adults were fed on healthy guineapigs twice a day. The feeding lasted from 4 to 10 minutes. Females, when reared in captivity, lay eggs on the 8th day. The insect takes its first food only 24 hours after emergence.

Transmission Experiments.

The transmission experiments were carried out on guineapigs and dogs. The reservoir of the trypanosomes was a guineapig that had previously been inoculated with blood obtained from a mule highly infected with surra. During the whole course of the experiments the animals were kept separate in insect-proof cages so as to prevent any possibility of infection from one animal to another. Daily records of the temperatures of the animals in the morning, mid-day and afternoon were taken, together with microscopic examinations of the blood.

Series A.

1. These experiments were carried out when trypanosomes were present in the peripheral circulation of the infected animal on which flies were fed. The feeding was carried out as follows: Flies were placed in tubes (6 in by 1 in.) covered with gauze of 1 mm. mesh, and then placed on the abdomen of the infected animal. As soon as the animal showed signs of being bitten, the flies were immediately removed and placed on healthy animals after intervals of 1 minute, 2 minutes, 3 minutes, 10 minutes, 30 minutes, 4 hours, and 24 hours. When the intervals between feeds were 4 hours and 24 hours respectively the flies were allowed to take a complete meal on the infected animals, which in every case were guineapigs.

The following table summarises the experiments:—

Expt. Number.	Number of flies used.	Number of trypanosomes in microscopic field.	Interval between infected and healthy feed.	Healthy animals on which transmission was made.	Results.
1	9	10–12	1 minute	Guineapig	+after 10 days
2	15	swarming.	5 ,,	,,	+after 9 days
3	10	10–15	30 ,,	,,	—after 90 days
4	15	swarming	4 hours	,,	—after 95 days
5	12	,,	24 ,,	,,	—after 90 days
6	20	,,	10 minutes	,,	+after 10 days
7	15	8–12	2 ,,	Dog	+after 10 days
8	15	,,	4 hours	,,	—after 90 days

2. (*a*) Ten flies were fed on an infected guineapig, which showed numerous trypanosomes in the peripheral blood, and afterwards were starved for two days; after this they were allowed to feed twice a day on a healthy guineapig, this being continued for six days. The healthy animal showed negative results up to 65 days after the last meal.

(*b*) Six flies were taken, fed as above on an infected animal and starved for three days, after which they were fed on another healthy guineapig for five days with two feeds a day. The results were negative up to 60 days after the last feed.

(*c*) Eight flies were taken and treated as in (*b*) and then fed on a healthy dog for four consecutive days. The results were negative up to 55 days after the last feed.

Series B.

Flies were fed on infected guineapigs that showed no trypanosomes in the peripheral blood, and then on healthy guineapigs at intervals of 2 minutes, 30 minutes, 4 hours and 24 hours, respectively. All the results were negative up to 80 days.

Series C.

1. Flies were dissected after copious feeding, from 10 to 15 minutes, on guineapigs that showed trypanosomes swarming in their peripheral blood. The dissections were made in normal saline solution 0·75 per cent.

The following table shows the results.

Number of flies treated.	Time of dissection after feeding.	Results.
5	1 minute	Trypanosomes very rare in the proboscis and motile. In the gut trypanosomes swarming and active.
8	5 ,,	Blood more or less coagulated in the proboscis. In the gut trypanosomes very active.
3	10 ,,	Same as for 5 minutes.
5	15 ,,	On proboscis blood dry. In gut blood slightly coagulated, trypanosomes very motile.
6	20 ,,	
5	30 ,,	Trypanosomes still very active in gut.
6	1 hour	Trypanosomes active. More clotting of blood in gut.
5	2 ,,	Trypanosomes found in some cases agglutinated; the membrane moving with about 120 undulations a minute.
4	3 ,,	Same as at 2 hours, except blood is more clotted and trypanosomes less active.
5	4 ,,	Complete clotting of blood in gut. Trypanosomes very rare, some disintegrated and flagellum rarely found.
6	12 ,,	Trypanosomes rare. Cytoplasm granular, disintegrated, with no flagellum or undulating membrane.
8	24 ,,	Blood completely coagulated. No trace of trypanosomes found.
8	24 ,,	Salivary glands and Malphigian tubes dissected with a view to detecting developmental forms, but results negative.

2. (*a*) Two series of five flies were fed on a surra-infected guineapig with trypanosomes in its peripheral blood; they were kept without food for two days, after which they were dissected in normal saline solution. Smears of salivary glands and gut were made, fixed in alcohol and stained with Leishman or Giemsa, but in no case were developmental forms found.

(*b*) Six flies were taken and fed as in (*a*), then starved for three days, after which they were dissected. No developmental forms were found in the salivary glands, gut, or Malphigian tubes.

(*c*) Eight flies were taken, fed on surra-infected guineapigs, starved for three days, and fed from that time on a healthy animal. Two of them were dissected on the fourth day, two on the fifth, two on the sixth and two on the seventh. In all cases the salivary gland, gut, and Malphigian tubes were free from trypanosomes.

It should be added that in all cases the healthy animals upon which the flies were fed remained healthy.

Summary.

1. The only biting fly of common occurrence in Mauritius is *Stomoxys nigra*.

2. The method of transmission of surra by *Stomoxys nigra* is direct, *i.e.*, it occurs when flies take a meal on a surra-infected animal, with trypanosomes in the peripheral blood, and immediately afterwards feed on a healthy animal.

3. Trypanosomes are found active in the proboscis of *Stomoxys* from one to ten minutes after a meal, when the temperature of the room is between 25 and 27° C.

4. No active form of trypanosomes can be found in the gut, Malphigian tubes or salivary glands of the fly 24 hours or longer after a meal on an infected animal.

5. For successful transmission the interval between the feeding on the infected and on the healthy animal must not be more than ten minutes.

6. Trypanosomes in the gut of *Stomoxys* are active from one minute to one hour after a meal on a surra-infected animal.

7. Trypanosomes are partially disintegrated, the cytoplasm becoming more granular and the flagellum disappearing, 24 hours after an infected meal.

8. No developmental forms of trypanosomes have been found in the salivary glands, gut or Malphigian tubes of *Stomoxys nigra* 24 hours or more after an infected meal.

9. When trypanosomes could not be found in the peripheral blood of a surra-infected animal, transmission could not be effected.

COLLECTIONS RECEIVED.

The following collections were received by the Imperial Bureau of Entomology between 1st April and 30th June, 1928, and the thanks of the Managing Committee are tendered to the contributors for their kind assistance :—

Mr. A. Balachowsky :—8 Orthoptera ; from Algeria.

Dr. C. F. C. Beeson, Forest Entomologist:—35 Curculionidae ; from the United Provinces, India.

Mr. A. G. Bennett : —39 Diptera and 43 larvae, and 5 Lepidoptera ; from the Falkland Islands.

Dr. F. S. Bodenheimer :—15 Diptera, 116 Coleoptera, 20 Parasitic Hymenoptera, 6 other Hymenoptera, 15 Lepidoptera, 3 Isoptera, 4 Spiders, and 4 Wood-lice ; from Palestine.

Mr. G. E. Bodkin, Government Entomologist :—14 Diptera, 43 Coleoptera, 8 Parasitic Hymenoptera, 6 other Hymenoptera, 26 Lepidoptera, 58 Isoptera, 90 Thysanoptera, 12 Rhynchota, and 6 Odonata ; from Palestine.

Dr. G. Bondar :—145 Coleoptera ; from Brazil.

Mr. H. E. Box:—2 Lepidoptera and 16 Rhynchota ; from the Argentine Republic.

Dr. P. A. Buxton, London School of Tropical Medicine :—23 Tabanidae, 156 other Diptera, 2 Lepidoptera, and 45 Hymenoptera ; from various localities.

Mr. E. C. Chubb, Durban Museum :—2 *Glossina*, 35 other Diptera, 21 Coleoptera, 87 Hymenoptera, 19 Rhynchota, and 7 Orthoptera ; from South Africa and Malta.

Chief Entomologist, Pretoria :—11 Coleoptera and 4 Chalcididae ; from South Africa.

Prof. T. D. A. Cockerell :—40 Culicidae, 63 other Diptera, 43 Coleoptera, 8 Hymenoptera, 46 Lepidoptera, 71 Rhynchota, 12 Orthoptera, 3 Ephemeridae, and 8 Odonata ; from various localities.

Mr. G. H. Corbett, Government Entomologist :—69 Diptera, 228 Coleoptera, 62 Parasitic Hymenoptera, 15 other Hymenoptera, 309 Lepidoptera, 39 Rhynchota, and 15 Orthoptera ; from the Federated Malay States.

Mr. A. Cuthbertson :—7 *Stomoxys*, 2 *Lyperosia*, 13 other Diptera, 72 Coleoptera, 49 Parasitic Hymenoptera, and 3 Rhynchota ; from Southern Rhodesia.

Director of Agriculture, Gambia :—53 Rhynchota ; from the Gambia.

Director of Agriculture, Mauritius :—2 Tabanidae, 5 other Diptera, 7 Coleoptera, 55 Parasitic Hymenoptera, 27 Rhynchota, and 2 Trichoptera ; from Mauritius.

Mr. V. H. W. Dowson :—2 Diptera, 1 Coleopterous larva, 5 Lepidoptera, 2 cocoons, and 15 eggs, and 1 Mite ; from Iraq.

Dr. H. Silvester Evans :—12 Culicidae, 3 *Tabanus*, 2 *Glossina*, 3 other Diptera, 2,330 Coleoptera, 15 Hymenoptera, 12 Lepidoptera, 5 Rhynchota, and 10 Orthoptera ; from Northern Rhodesia.

Mr. T. Bainbrigge Fletcher, Imperial Entomologist :—219 Orthoptera ; from India.

Mr. C. Franssen :—6 Rhynchota ; from Java.

Mr. J. G. H. Frew :—291 *Glossina*, and 34 other Diptera ; from Sierra Leone.

Dr. C. Fuller :—77 Coleoptera ; from Portuguese East Africa.

Mr. J. C. M. Gardner :—62 Parasitic Hymenoptera ; from the United Provinces, India.

Mr. F. D. Golding, Government Entomologist :—44 Coleoptera, 4 Hymenoptera, 9 Rhynchota, and 4 Orthoptera ; from Southern Nigeria.

Mr. W. Greenwood :—28 Diptera, 2 Parasitic Hymenoptera, 27 Lepidoptera, 7 Thysanoptera, and 2 species of Coccidae ; from Fiji.

Mr. E. Hargreaves, Government Entomologist :—4 *Tabanus*, 24 other Diptera, 175 Coleoptera, 3 Parasitic Hymenoptera, 14 other Hymenoptera, 48 Lepidoptera, 5 species of Coccidae, 56 other Rhynchota, 17 Orthoptera, and 5 Planipennia ; from Sierra Leone.

Mr. H. Hargreaves, Government Entomologist :—2 Culicidae, 4 Tabanidae, 13 other Diptera, 98 Coleoptera, 10 Parasitic Hymenoptera, 5 other Hymenoptera, 71 Lepidoptera, 8 species of Aphidae, 35 species of Coccidae, and 39 other Rhynchota ; from Uganda.

Mr. G. V. Hudson :—29 Coleoptera, 18 Lepidoptera, and 26 Rhynchota ; from New Zealand.

Mr. T. W. Kirkpatrick :—35 Chalcididae ; from Kenya Colony.

Mr. J. W. McHardy :—1 Tick ; from Tanganyika Territory.

Prof. F. J. Meggitt :—50 Siphonaptera, 16 Nycteribiidae, 6 other Diptera, 101 Coleoptera and 8 larvae, 24 Chalcididae and 5 egg-masses, 6 other Hymenoptera, 22 Lepidoptera and 120 early stages, 17 Isoptera, 2 species of Aphidae, 2 species of Coccidae, 217 other Rhynchota, 214 Orthoptera, 3 Planipennia, 15 Ant-lion larvae, 50 Mallophaga, 25 Odonata, and 5 Spiders ; from Burma.

Mr. N. C. E. Miller :—1,374 Orthoptera ; from Tanganyika Territory.

Mr. H. M. Morris, Government Entomologist :—26 Diptera, 71 Coleoptera, 25 Chalcididae, 20 other Hymenoptera, and 13 Rhynchota ; from Cyprus.

Natal Museum, Pietermaritzburg :—2 Diptera and 4 Rhynchota ; from South Africa.

Prof. G. Paoli :—100 Braconidae ; from Italian Somaliland.

Mr. F. S. Parsons :—6 Diptera and 3 pupa cases, 4 Chalcid preparations, and 4 Formicidae ; from Natal.

Mr. F. A. Perkins :—2 Diptera ; from Queensland, Australia.

Mr. A. W. J. Pomeroy, Government Entomologist :—32 Tabanidae, 29 *Glossina*, 3 *Stomoxys*, 6 Hymenoptera, and 2 Ticks ; from the Gold Coast.

Mr. Y. Ramachandra Rao, Government Entomologist :—116 Coleoptera, 16 Lepidoptera, 38 Thysanoptera, and 6 Orthoptera ; from South India.

Mr. G. Samuel :—120 Thysanoptera ; from South Australia.

Dr. H. Schouteden :—30 Diptera, 5 Coleoptera, and 7 Lepidoptera ; from the Belgian Congo.

Mr. H. W. Simmonds, Government Entomologist :—3 *Stomoxys*, 16 other Diptera, 4 Coleoptera, and 2 Formicidae ; from the Fiji Islands.

Mr. E. R. Speyer :—200 Parasitised Aleurodid pupae on tobacco leaves ; from Cheshunt, Herts.

Dr. P. Tchorbadjiev :—19 Coleoptera, 47 Hymenoptera, and 20 Lepidoptera ; from Bulgaria.

Mr. O. Theodor :—3 Diptera and 452 Coleoptera ; from Palestine and Sinai.

Mr. H. P. Thomasset :—8 Diptera, 63 Coleoptera, 9 Parasitic Hymenoptera, 9 other Hymenoptera, 305 Lepidoptera, 52 Rhynchota, 14 Orthoptera, 7 Ephemeridae, 7 Trichoptera, and 2 Planipennia ; from Natal.

Dr. W. R. Thompson :—26 Collembola ; from France.

Mr. R. H. van Zwaluwenburg :—35 Coleoptera ; from Hawaii.

Mr. P. Vayssière :—2 Parasitic Hymenoptera ; from Morocco.

Mr. R. Veitch, Chief Entomologist :—34 Diptera and 31 pupa cases ; from Queensland, Australia.

Wellcome Tropical Research Laboratories, Khartoum :—40 Diptera and 40 Larvae, 113 Coleoptera, 18 Parasitic Hymenoptera, 26 other Hymenoptera, 20 Lepidoptera, 32 species of Coccidae, 147 other Rhynchota, and 171 Mallophaga ; from the Sudan.

Mr. H. Wilkinson :—22 Scolytidae ; from Kenya Colony.

Mr. C. B. Williams :—8 Crustacea ; from Tanganyika Territory.

Mr. G. N. Wolcott :—1 Weevil ; from Peru.

Mr. R. C. Wood :—4 Culicidae, 12 Tabanidae, 18 other Diptera, 147 Coleoptera, 29 Lepidoptera, 18 Rhynchota, and 2 Orthoptera ; from Nyasaland.

Dr. F. Zacher :—22 Coleoptera and 1 Moth ; from Colombia.

Zoological Museum, Hamburg :—511 Curculionidae ; from Africa.

THE SIREX WOOD-WASPS AND THEIR IMPORTANCE IN FORESTRY.

By R. N. Chrystal, Hon. M.A. (Oxon.), B.Sc. (For.) (Edin.).

(Plates IX–XI.)

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Introduction.

This paper on the biology and forest relations of certain British wood-wasps or "horntails" (Hymenoptera, Siricidae), which is based upon some studies recently carried out at Oxford (1926–27), was originally inspired by the recent accounts that have appeared concerning the destructive activities of one of the steel-blue species in New Zealand. There the wood-wasps are causing considerable anxiety on account of their attacks on *Pinus radiata*, and quite recently the New Zealand Government approached the Imperial Bureau of Entomology with a request that their newly established parasite laboratory at Farnham Royal, Bucks., might take up the study of the wood-wasp parasites, with a view to their collection and exportation to New Zealand. I have had the pleasure of co-operating with the Bureau in this work and this paper is intended to serve as an introduction to a later publication on the parasites of the woodwasps, which will be published subsequent to the completion of certain investigations now proceeding. A preliminary paper on the parasites of the wood-wasps has already been published (Bull. Ent. Res., xix, pp. 67–77).

The objectives in the present work have been threefold: to review the literature of the Siricidae up to date; to present the results of some recent studies made by myself on the biology and forest relations of two British species; and, lastly, to touch briefly on the *Sirex* problem in New Zealand, with particular reference to the question of control measures. I should like at this point to acknowledge my indebtedness to Dr. J. G. Myers, of the Imperial Bureau of Entomology, for helpful criticism; to Dr. James Waterston, of the British Museum (Natural History), who has kindly contributed some systematic notes on the British wood-wasps, which are published here by kind permission of the Trustees of the British Museum; to the President and Fellows of Magdalen College, Oxford, for their kindness in granting access to the wood at Tubney, near Oxford, where most of the work has been carried out; and to Mr. H. S. Hanson, of South Molton, North Devon, who has helped materially with specimens and personal records from that district.

Systematic Notes on British Wood-wasps.*

While the determination of any of the *Sirex* species occurring in Britain seldom presents special difficulties, their tabulation is by no means easy owing to the

* By Dr. James Waterston.

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notorious instability of the available characters. Particularly is this the case with the neuration. Thus, *S. gigas* occasionally shows a first transverse brachial vein completely or imperfectly developed. British *S. noctilio* apparently have this vein incomplete, but in continental examples it may be fully developed. The neuration

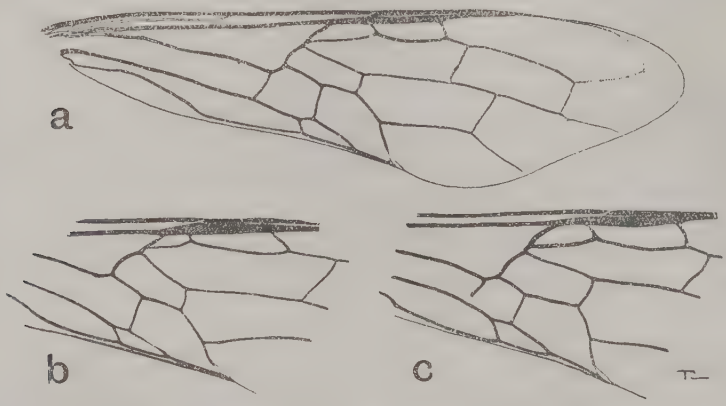


Fig. 1. Neuration of forewing: *a, Sirex cyaneus; b, S. gigas; c, S. noctilio.*

of *S. cyaneus* appears to be more constant, but (though rarely) it is not invariably to be relied upon.

The ♂ genitalia, at least in larger examples, can be drawn out in fresh specimens and studied in this way. The outer lobe (squamula) of the stipes appears to be

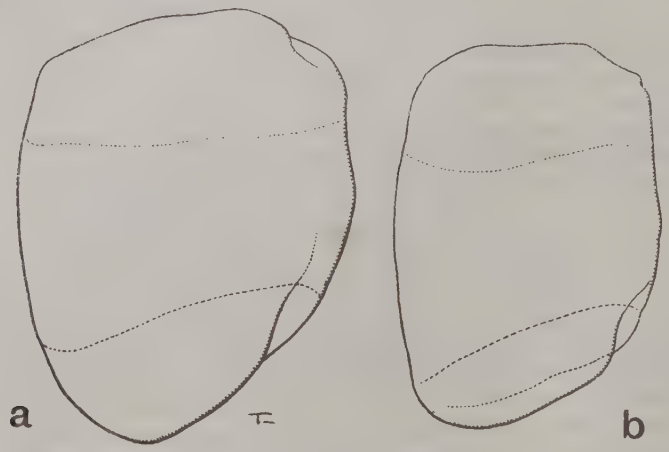


Fig. 2. Genitalia—apical appendage (squamula) of stipes: *a, Sirex noctilio; b, S. cy neus.*

narrower and straighter ventrally in *cyaneus* than in *noctilio*, and there are other differences in the apparatus seen from below.

As regards the synonymy of *Sirex* I have followed Bradley (1913) (*vide infra*).

Curtis (1829) designates *S. juvencus*, L., as the genotype. His figure and description apply to *S. noctilio*, Fab. Fortunately, however, this in no way alters the application of the name.

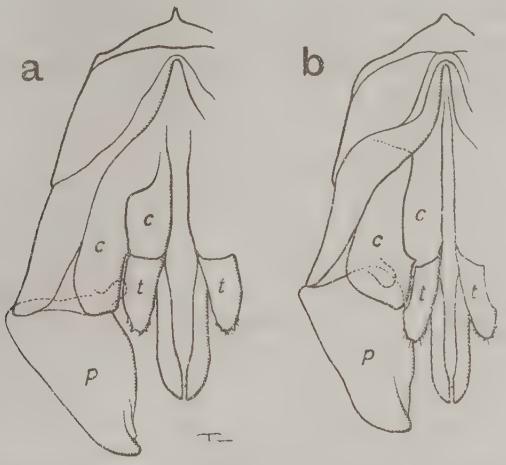


Fig. 3 Genitalia—from below: *a, S. noctilio; b, S. cyaneus.* (Lettering corresponds to that in Boulangé's monograph.)§

Normal examples of the four wood-wasps now occurring in Britain may be separated by the following key.

1. Head with a conspicuous yellow spot on the temples behind each eye; vertex *broadly black* separating the spots widely. Forewings with *one* transverse brachial nervure (fig. 1, *b*) ... ... *gigas*, L.
   Head immaculate; *two* transverse brachial nervures (fig. 1, *a*, *c*) 2
2. Females 3
   Males 5
3. Projecting portion of the ovipositor sheath, seen from above, nearly as long as tergites ix+x; first transverse brachial nervure complete *cyaneus*, F.
   Projection of sheath never much longer than tergite x; first transverse brachial nervure usually incomplete 4
4. Antennae wholly infuscated or black; cornus sub-equilateral; impression on tergite ix distinctly transverse; sheath distinctly shorter than tergite x *noctilio*, F.
   Antennae with scape (whole or part), pedicel and 3–5 normal funicular joints clear testaceous or ferruginous; cornus elongate triangular; impression variable, never distinctly transverse; sheath and tergite x subequal *juvencus*, L.
5. Apex of abdomen from the 8th segment black with (more or less) submetallic reflections; all femora darkened, and in the hind legs black except narrowly at apex; first transverse brachial nervure generally incomplete *noctilio*, F.
   Apex of abdomen and all femora ferruginous (the contrast between femur and tibia striking in the hind leg) 6
6. Antennae basally rufescent or pale; 1st transverse brachial nervure incomplete *juvencus*, L.
   Antennae entirely infuscated or black; 1st transverse brachial nervure complete *cyaneus*, F.

§ Boulangé, Mém. Trav. Facultés catholiques Lille, xxviii, 1924.

Sirex (*Urocerus*) *gigas*, L.

This, our only representative of the subgenus *Urocerus*, is a conspicuous yellow and black species, which is easily recognised. The large black spot (about as wide as two-thirds of the vertex) separating the paler ones on the temples distinguishes this species in both sexes from others found in the Palaearctic Region, e.g., *augur*, Kl., *fantoma*, F., *cedrorum*, Sm., *japonicus*, Sm., *xanthus*, Cam., in which there is at most a narrow darker line extending backwards behind the anterior ocellus, and hardly

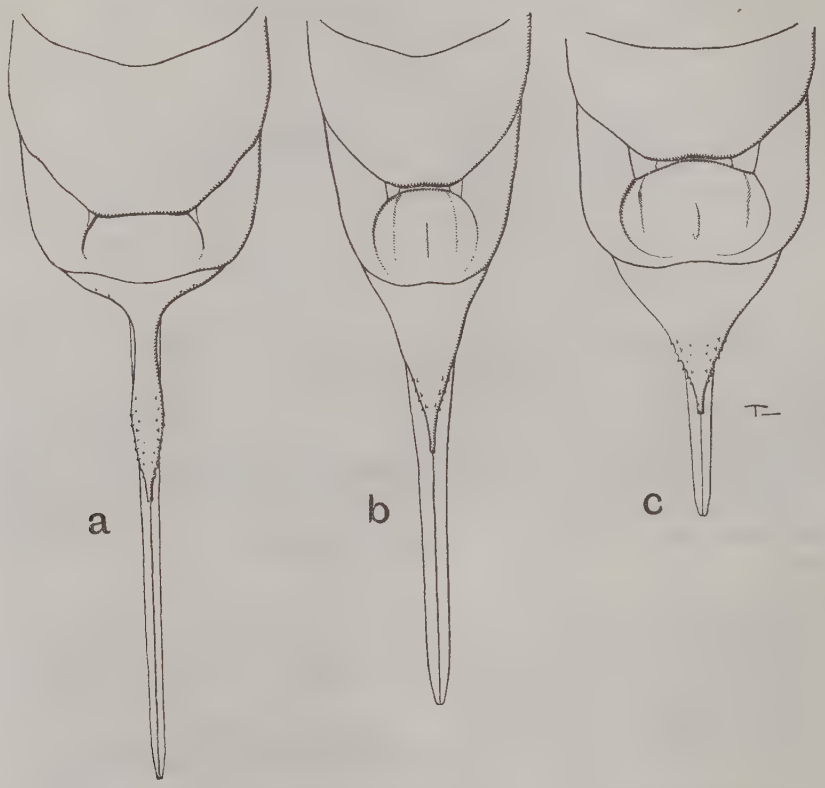


Fig. 4. Abdominal segments viii–x, dorsal view: *a*, *S. gigas*; *b*, *S. cyaneus*; *c*, *S. noctilio*.

wider than this organ. Confusion, however, may arise between *U. gigas*, L., *U. flavicornis*, F. (♂, ♀) and *U. albicornis*, F. (♀) (both North American). The first two may be separated as follows :—

U. gigas.

♂. Scape variable (black, black and yellow, or yellow) ; flagellum yellow, as is also tergite vii. Tergite ii infuscated, as a rule, only along anterior edge, and not to beyond one-half posteriorly.

U. flavicornis.

♂. Scape black ; flagellum basally ferruginous, and distally infuscated (*i.e.*, from 6th–8th joint to apex, which may be black). Tergite vii black ; tergite ii more extensively infuscated, pale mainly at sides.

♀. Tergite viii entirely yellow; tergite ix infuscated basally (sometimes only at sides), pale (yellow) broadly towards apex; tergite x wholly yellow.

♀. Tergite viii yellow only on basal third, black beyond; tergite ix wholly black; tergite x black, only the spike yellow.

According to Professor J. C. Bradley (J. Ent. & Zool. v, p. 19, 1913) the males of *U. albicornis* and *U. flavicornis* are indistinguishable.

In the British Museum are two males (Hudson's Bay) placed under *albicornis*, F., by the late F. D. Morice. These can be separated from *flavicornis*, F., by the more elongate hind tarsus, in which the first joint is slender, nearly seven times as long as wide, whereas in *albicornis* (Nova Scotia) this joint is barely five times as long as broad. In ♀ *albicornis* the abdomen is wholly black save for a pale spot at the side on tergite viii. Both of these North American species have occurred in England in the London District, and their captures have resulted in regrettable additions to synonymy; *U. albicornis*, F., was thus re-described as *Sirex stephensi*, Kirby 1882, and *U. flavicornis*, F., as *Sirex bizonatus*, Steph. 1835. The type of *U. stephensi* and cotypes (?) of *U. bizonatus* are still extant in the British Museum. *U. augur*, Kl., is also reported to have occurred in Britain, but I have seen no example so taken.

Sirex noctilio, F.

In the male this species is recognisable at once by the colour of the legs, antennae and abdomen (apex), as well as by the usually imperfect first transverse brachial nervure. The first two, and part of the third tergites are dark, and more or less metallic. The darkening of tergite iii may reach back to two-thirds, but it is generally incomplete laterally. In the female the abdomen is stout and broad, parallel-sided to the end of the 9th segment, and rather abruptly pointed on the 10th tergite.

The general surface of tergites ii–viii is dull blackish, and remains so however the insect is turned. Tergite i, beyond the usual large punctures, is smooth and shining, especially along the posterior margin.

Sirex cyaneus, F.

♂. Abundantly distinct from *S. noctilio*, F., but separable from ♂ *S. juvencus* sometimes only by the colour of the antennae; tergites i and ii wholly, iii on disc, and iv (a basal spot or spots) blue-black.

♀. The abdomen is more slender and tapers gradually from the middle of the 8th segment. The impression on tergite ix is subcircular, and at its bottom clearly longer than broad. The general surface of tergites ii–viii is dark blue from above, and distinctly coerulescent from other angles. Tergite i, beyond the usual large punctures, is faintly scaly reticulate and hence not brilliantly shining on the posterior half.

Sirex juvencus, L.

♂. See note under *cyaneus*, F.

♀. Distinguished by the incomplete transverse nervure, and the basally rufescent antennae. In the abdomen rather more like *cyaneus* than *noctilio*, but the ovipositor is slightly shorter than in the former, and the cornus a trifle narrower than in the latter.

The colour of the forewings, in the specimens of *juvencus* in the British Museum, is noticeably darker on rather more than the apical half, *i.e.*, from the level of the first cubital cell. In *noctilio* and *cyaneus* the wings are sub-hyaline and more or less broadly infuscated along the outer margins.

Status of the Species discussed.

Only in the case of *S. juvencus*, L., can any doubt arise as to the application of the name or the status of the insects determined by the above key. The name must

be used to designate a blue-black *Sirex* with the antennae basally rufescent, and Evans (Scottish Naturalist, p. 176, 1922) has pointed out that the male of *S. noctilio* may show this character—probably owing to immaturity. Evans' specimens had the apex of the abdomen dark and were found in galleries in timber, with ♀♀ clearly *noctilio*.

The ♂ of *S. cyaneus* (*i.e.*, reared with normal females of that species) may show on both wings an incomplete first transverse brachial nervure, and if the pale colour of the antennae basally can be due to immaturity, such a specimen would be indistinguishable from *S. juvencus* ♂.

The ♀ of *S. juvencus* is much more definable than the ♂. The ovipositor is relatively longer than in *noctilio*, and shorter than in *cyaneus*. The cornus, too, seems to be intermediate in shape, but I have not seen enough material to offer a decided opinion. In discussing these blue-black wood-wasps I have quite deliberately avoided using the longitudinal impression on the vertex, and the rugulosity of the saw-sheath as characters. They seem to me too variable to be relied upon. The tarsal characters noted by Thomson require further elucidation, and have not been dealt with here.

Status as British Insects.

U. gigas, *S. noctilio* and *S. cyaneus* are at the present day thoroughly established in Britain, but the position of *S. juvencus* is more doubtful. Examples of all four taken by J. F. Stephens are still extant in the British Museum.

No one, however, has yet collected and critically analysed the records of *Sirex* taken in England, though such a work might throw interesting light on the progress of the invader *S. cyaneus*. Since the War *U. gigas* and *S. cyaneus* have frequently been sent to the writer for determination, while true *S. noctilio* appears to be less common. *S. juvencus* has been received only twice, on each occasion probably as an importation.

Mr. Evans' notes on the wood-wasps (*Sirex*) in Scotland, already referred to, give an admirable summary of the subject. *U. gigas* was first recorded as a Scottish insect in 1813, and has now been reported from thirty of the Watsonian counties and vice-counties. It is absent, indeed, only in the extreme north and certain of the islands.

"Blue-black" wood-wasps have been known for fifty years in Scotland, and have now been noted in fourteen of the Watsonian areas. In nine (probably ten) of these *S. cyaneus* has been identified, and in two *S. noctilio*. In one county (Linlithgow) the latter species has been definitely proved to be established.

General Review of Sirex Literature.

Continental.—The important continental literature on the biology and forest relations of the SIRICIDAE dates from the beginning of the 19th century, and the earliest papers are of German origin. J. M. Bechstein was one of the pioneer workers and devoted a section of his "Forstinsektologie," published at Gotha in 1818, to the family, in which he gave a general account of the morphology and biology of *S. gigas* and *S. juvencus*, his work being chiefly remarkable for the statements made as to the predatory habits of the adults, which will be discussed later on. Bechstein's work together with that of other contemporary observers was summarised by Ratzeburg in 1844 in his great work "Die Forstinsekten," which contains a detailed description of the morphology and biology of the two species mentioned above, and also discusses at some length the forest relations of the species with special reference to their appearance in forests that have been severely damaged by defoliating insects. This work must be regarded as the principal source from which many subsequent writers derived much of their material. After Ratzeburg's time the next important contribution to the literature was Hartig's "Die Familien der Blatt-und Holzwespen," which appeared in 1860. In the section of this book that deals with the SIRICIDAE, Hartig

gives a very complete account of the larval life of *S. juvencus*, which includes some valuable observations on the characteristics of its larval tunnels and the nature of the frass. He also deals with the question of *Sirex* as an enemy of green trees and compares its status as a primary pest with that of the bark-beetles, which he regards as being immeasurably more important. Describing the life of the adults in detail he criticises at some length Bechstein's statement that they prey on other insects and cites the observations of other writers on the same subject. He concludes his account of the family with a complete systematic review. Taschenberg's textbook, "Forstwirtschaftliche Insektenkunde," followed Hartig's work in 1874, and in this a useful review of the family is given, chiefly based on the work of previous writers, some of whose errors are repeated. He deals almost entirely with *S. juvencus*, giving only a very brief account of *S. gigas*. André's book, "Species des Hyménoptères d'Europe et d'Algerie," followed Taschenberg in 1879, and in this a small section is devoted to the family. The biological notes on the species, which largely follow Bechstein's work, contain numerous errors and do not give any data regarding host trees. A long list of insect parasites is given without any data referable to their occurrence, and this was apparently drawn upon by Rudow in 1919, who quotes a similar list, without however furnishing any further details. In 1881 there appeared a paper by Wachtl entitled "Die Stahlblau Fichten- und violette Kiefernholzwespe *S. juvencus* Linne und *S. noctilio* Fabr.", in which he gave a complete morphological comparison of these species in the form of parallel keys, and also dealt briefly with their biology and distribution.

Eight years later, in 1889, Herman Borries, a Danish entomologist, published a paper on the "Occurrence and Distribution of Insect Pests in the Danish Conifer Forests." A section of this paper is devoted to the SIRICIDAE and gives a brief account of the distribution of *Sirex* in Denmark, together with some biological observations, some of the most valuable of which are those concerning the pairing habits.

In the year 1895 there appeared Judeich & Nitsche's "Forstinsektenkunde," which was published as the 8th edition of Ratzeburg's "Die Waldverderber und ihre Feinde." In this book a very complete review of the SIRICIDAE is given, covering not only the systematic side of the subject but also dealing in full detail with the biological aspect. The references to previous workers are very complete, and this work forms an indispensable guide to all literature published up to that time.

From 1895 up to the present day the most important continental works on the subject are Enslin's monograph "Die Blatt-und Holzwespen," in Vol. iii of Schröder's "Insekten Mitteleuropas," Stuttgart, 1914, and Scheidter's recent paper on the biology of *S. augur* and *S. gigas* in Bavaria published in 1923. Enslin's work contains a useful introduction to the biology of the Tenthredinoidea as a whole, and gives well illustrated systematic keys to the families and a comprehensive bibliography of the literature on the group. Scheidter's paper is valuable for its biological detail and includes several hitherto unrecorded observations on the oviposition of *S. gigas*, which will be dealt with subsequently in a comparison of the habits of this species with those of *S. cyaneus*.

British Literature.—The earliest reference to *Sirex* in Britain that I have been able to find occurs in Martyn's edition of Moses Harris' "Exposition of British Insects," London, 1792. The wood-wasp referred to, which is described and figured together with its larva under the name of *S. torvus*, is one of the steel-blue species and bears a strong resemblance in the length of its ovipositor to *S. cyaneus*. It is interesting to note that, discussing the identity of the species, Harris has grave doubts as to its being synonymous with *S. juvencus*, L. The larva is noted as living in dead wood.

Donovan (Natural History of British Insects, xi, London, 1806) records *S. juvencus* as having been taken in a London dwelling-house. He describes the species as a wood borer, but gives no further details. The figure of the insect, which is excellently reproduced on a full-page plate, is almost certainly that of *S. cyaneus*. Curtis (British

Entomology, vi, London, 1829) refers to two species of *Sirex*, *S. gigas* and *S. juvencus*. He records *gigas* from Norwich, Wilts, Kent, Berks, and near London ; and *juvencus* from fir (?) groves in Norfolk, Suffolk, Hants and Yorkshire. Some interesting biological details are given by him in respect of material received from the Hon. Chas. Harris, of Heron Court, Gloucestershire. This was obtained from some fir (? pine) trees that had suffered severely from heat and drought during the summers of 1825 and 1826. The adult wood-wasps were taken only in dead trees and eight males are recorded as emerging simultaneously. These, he relates, proved to be strong on the wing, and when released immediately rose to a considerable height. This, as we shall see, probably bears out a statement by Borries on the habit of the males at pairing time. Large numbers of males, he continues, were found during the same year (1826) flying round the towers of York Minster. These, he says, were probably seeking females, which were issuing from timbers used in supporting the roof. Shuckard (Magazine of Natural History, 1837) records *S. cyaneus* (*duplex*) from black spruce (*Picea nigra*) in Cambridgeshire, emerging at the end of May and early June. He gives no biological details, however. Three years later, in 1840, Westwood published his Introduction to the Modern Classification of Insects, in Vol. ii of which he devotes a small section to the morphology of *S. juvencus*, dealing especially with the structure of its ovipositor. He quotes an interesting record of the occurrence of this species from Bewdley Forest, Worcestershire, communicated by Mr. Raddon. During the first part of the season (1836) the proportion of females to males was only 1 in 12, while during the latter part, *i.e.*, the last 2 to 3 weeks, only females appeared. The wood-wasps continued to emerge until the end of November.

In 1882 W. F. Kirby's list of the Hymenoptera in the British Museum appeared, and in this *S. cyaneus* is recorded as having been taken by Stephens, Shuckard and Lubbock. Lubbock's specimens were bred from larch, but otherwise no record of host trees is given. From 1887 up to the present day the most important contributions to the literature include the following works :—Cameron's "Monograph of the British Phytophagous Hymenoptera," which is entirely systematic ; Morice's "Help Notes towards the Determination of British Tenthredinoidea," also systematic ; and the works of Miss Ormerod (Manual of Injurious Insects and Methods of Prevention, pp. 256–260, 1890), MacDougall (1907) and William Evans (1922).

Evans' paper is the most comprehensive account of the SIRICIDAE that has so far appeared in this country. He gives a complete historical account of the records of *Sirex* in Scotland, which is supplemented by statistical details. His biological notes, which will be discussed more fully later on, are also most valuable.

American Literature.—The American literature on the SIRICIDAE attacking conifers is, practically speaking, apart from systematic papers by Bradley and others, confined to brief records of their occurrence. Felt in his "Insects of Park and Woodland Trees," 1905, refers briefly to two species, *Sirex* (*Urocerus*) *albicornis*, F., and *Sirex* (*Paururus*) *cyaneus*, F., but the majority of other writers are content with simple records of their capture and locality. No really comprehensive account of the biology of any American species attacking conifers has appeared as yet.

Biology of S. cyaneus and S. gigas in Britain.

The major portion of the biological work has been carried out on *S. cyaneus*, this species being the only one present in the larch wood at Tubney where most of the field work was done.

Flight Period and Habits of the Adults.

The flight period of the two species overlaps to a considerable extent. *S. gigas* appears earlier and is found on the wing from June onwards until the autumn. My own records of the flight of this species during 1927 do not extend beyond 9th September, but Evans records their appearance in the South of Scotland in early October.

S. cyaneus appears as a rule towards the end of July or even later, according to the season. In 1927, for example, the flight did not become general until mid-August and the last adult was seen on 23rd September. I have no record of its appearance in flight as late as October, although Evans records finding the insect flying as late as 6th October. The flight period for both species is at its height from July to September, and this is in general agreement with the observations of Continental workers such as Hartig, Taschenberg and others. All the adults that emerged at Tubney developed, to the best of my knowledge, from larvae that had pupated some 5 weeks previously. Cases are known, however, of the insects wintering in the adult stage, and I have recently seen examples of this in both species from silver fir logs at South Molton, North Devon. I have never found *S. cyaneus* overwintering in the larch at Tubney, nor do I consider that it is by any means a common occurrence, as it seems probable that adults remaining thus in the wood over winter might be exposed to the grave danger of fungus attack, due to over-moist conditions. Further reference to the finding of emerging adults covered with fungus mycelium is made on page 000. The adults fly in bright sunlight and when in flight make a noisy buzzing sound, which has been well described by the German writers by the word "schwirren," the onomatopoeic significance of which must instantly strike anyone who has heard the insect when in flight. Bechstein, describing the flight habits, says of *S. gigas*: "The wood-wasp flies in the warm months of July and August, when pairing takes place, and the adults live by preying on other weaker insects, for example, flies"; and in another place, referring to *S. juvencus*, he writes: "This insect preys on other insects upon which it feeds." This view of the *Sirex* adult as a predator is not peculiar to Bechstein; Hartig also quotes the observations of an old writer, Jordens by name, who recorded the wood-wasps as predacious on the adults of the nun moth (*Lymantria monacha*), which he said were captured on the wing. Another writer, Thiersch, is also quoted by him to the same effect, viz.:—"The wasps not only feed on the sap of trees, *e.g.*, silver fir, etc., but also on small insects which they catch on the bark of trees and also in flight." The predatory habit is also referred to by Taschenberg, who states that the adult wood-wasps capture now and again small insects in flight, in a similar fashion to the large sawflies of the genus *Tenthredo*.

Hartig views the above statements with grave doubt and regards the evidence upon which they are based as being insufficient. With the latter view I am inclined to agree, and certainly no record of predatory habits on the part of the wood-wasps has been made by myself, nor can I find any mention of it in the British literature. The females are much the most commonly observed either on the wing, or at rest upon the bark of trees. This indicates a marked preponderance of females over males, and Scheidter observes in this connection that in a catch of several hundred adults of *S. augur* only 10 were males, and of *S. noctilio* only in one case was the majority of a catch composed of males, this having been probably made at a time when the males were just emerging and were easily caught. My own records of *S. cyaneus* also show a marked excess of females over males, the proportion being almost 2 : 1 over a period of two years, and recent figures from North Devon indicate a similar state of affairs.

During the flight period in Tubney Wood males were seen on only three occasions, once resting on the bark of a tree about 6 feet from the ground, and twice flying at a considerable height. Apropos of this, Borries quotes an observation made by Drewsen at Strandmöllen in Denmark, that wood-wasps pair in the tree-tops, after which the females descend to the lower levels for egg-laying. In the work at Tubney this summer pairing was never observed in the open, although it occurred in the cages on two occasions. The observation quoted above offers a reasonable explanation of the failure both to find adults pairing in the open, and also to observe many males in flight.

Oviposition.

Oviposition proceeds with great vigour in warm and sunny weather, but the wasps also show some activity on cloudy days and even when rain is falling. In very wet weather it is more usual, however, to find them sheltering in bark crevices. Hartig observed that the adult females of *S. juvencus* swarmed at sundown, and Scheidter also states that the females of *S. augur* and *S. noctilio* oviposited only in the late afternoon. I have found no evidence of time selection in either *gigas* or *cyaneus*, *e.g.*, *gigas* was found ovipositing in the middle of the day, while *cyaneus*, commencing about 10 a.m., would continue throughout the day until the early evening, in some cases without any marked interval of rest. Oviposition was observed in both species, in *S. gigas* on 8th July, and in *S. cyaneus* on many occasions from August until late September. *S. gigas* was found ovipositing in a sawmill where there was a considerable quantity of larch and pine logs and sawn timber. The insect selected a small freshly

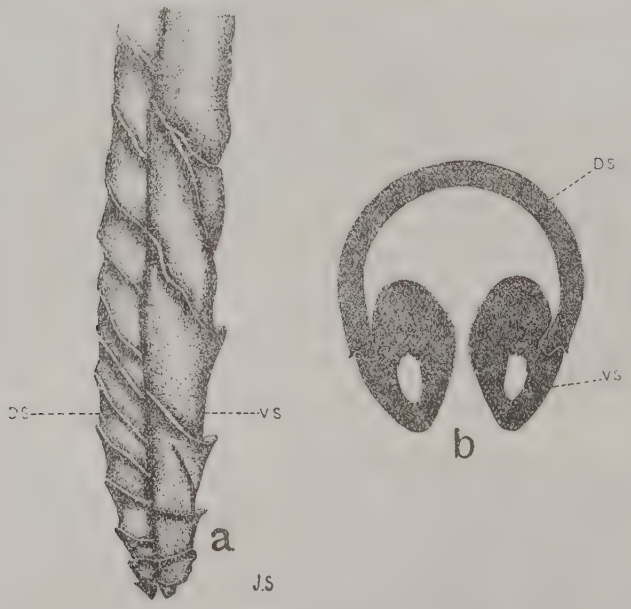


Fig. 5. Ovipositor of *S. cyaneus*; *a*, apex, showing the serrated setae, ×35; *b*, transverse section, showing the ventral valves (v.s.) slightly separated from one another, ×70. d.s. = dorsal seta, v.s. = ventral seta.

cut larch log and began its task at 11.25 a.m., boring three oviposition tunnels in the course of half an hour, each operation lasting 8–9 minutes. Two of these tunnels, on subsequent examination, failed to reveal any sign of eggs, and it was thought at first that these had been overlooked. It was discovered later, however, that the insect frequently makes trial borings, sometimes of considerable depth, in which, for some reason or another, she fails to oviposit.

Before boring commences, a close examination of the bark is made with the antennae, this operation being followed by further preliminary testing with the ovipositor and sheath, which may be withdrawn several times before a favourable spot is found. Having chosen the place of oviposition the insect raises herself upon the two outer valves that form the sheath of the ovipositor. Once she is firmly established in the desired place, the latter are released and spring back to their original horizontal

position, exposing the thin flexible tube-like ovipositor which the insect proceeds to insert into the wood with a rapid sawing movement of the toothed setae, the whole operation being accompanied by rhythmical movements of the abdomen.

It is at this point that the first egg is laid at the bottom of the tunnel. Subsequently the ovipositor is gradually withdrawn, coming to rest several times during the process. From the position of the eggs in the tunnel, lying as they do one above the other, it seems very probable that each halting place of the ovipositor represents the deposition of another egg. The halting of the ovipositor while being withdrawn is not, however, to be confused with the sawing action of the organ while the oviposition tunnel is still in course of construction.

The ovipositor (fig. 5) in transverse section can be divided into 3 parts, a dorsal valve, representing the fused inner gonapophyses of segment 9, and two ventral valves developed from the gonapophyses of segment 8.

The outer dorsal portion of each ventral valve is deeply grooved to enable the flanged portion of the dorsal valve to fit closely into it. The egg tube is formed by the

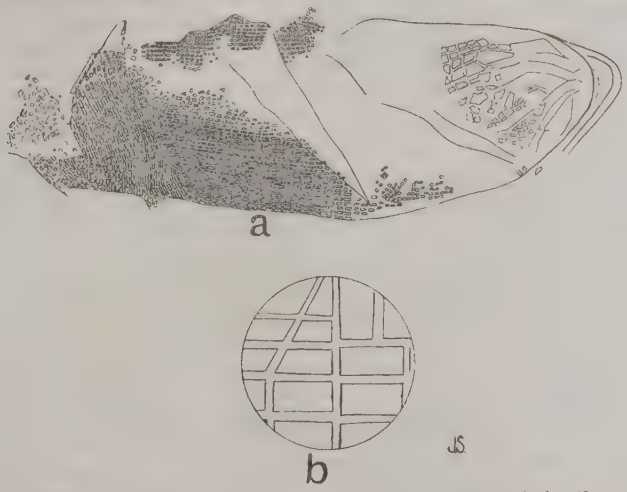


Fig. 6. Egg of *S. cyaneus*: *a*, sheath, × 60; small portion of sheath, × 225.

union of these valves, and if the ovipositor of an adult be examined at the time of egg laying the tube will be found full of eggs which are passing down into the oviposition tunnel. The diameter of the egg tube when empty is 0·27 mm., and on comparing this with the average diameter of the eggs which pass down it, it was found that these measured 0·36 mm. at their widest part, consequently exceeding the diameter of the egg tube by 0·09 mm. This difference in diameter is fairly constant, and the question arises as to how the egg passes down the tube into the oviposition tunnel. This is probably effected by a slight flattening out of the egg as it passes down the tube, proof of which has been found in eggs dissected out of the tube, and further the fact that the egg tube is oval in shape rather than circular confirms this ; moreover a lubricant fluid also assists the eggs in their passage down the tube. This fluid has been observed exuding from the tip of the ovipositor of *S. cyaneus* during the discharge of the eggs. Further, it has been found in all cases that the eggs are surrounded in the oviposition tunnel by a white glistening sheath of a glutinous nature.

This sheath coats the tunnel walls and also the eggs, from which it is extremely difficult to remove it. Under the microscope it always breaks up into a constant pattern (fig. 6) which somewhat resembles crystalline structure.

I found no trace of any such covering on the eggs that were still lying in the egg tubes, and therefore conclude that this substance is a glandular secretion, which, passing down the oviduct into the ovipositor, acts as a lubricant for the passage of the eggs. Burmeister (Manual of Entomology, p. 190, pl. xxvii, fig. 10) describes and figures a glandular appendage in the female reproductive organs of *S. gigas*, which he calls the gum gland. This, he says, contains a white glutinous liquid that covers the eggs and fastens them to " objects." He does not, however, figure the nature of this covering, so I am unable to compare my findings with his. Lastly, the eggs are assisted in their passage down the tube by the opening out of the two ventral valves, which increases the diameter of the tube. The actual occurrence of this can be seen when oviposition is in progress, as the eggs are sometimes visible passing down the tube through the slit formed by the opening out of the two ventral valves. The inner margins of these are covered with closely placed hairs, and it is possible that when they separate from one another the hairs act as a protection against the entry of foreign bodies, e.g., wood frass, etc., which might block up the egg tube. Close observation of oviposition is a simple matter, as the insect, completely absorbed in her task, allows one to follow her movements even with a hand lens. The oviposition habits of *S. cyaneus* do not differ in their essentials from those of *gigas*, but several instances were recorded in which the operation lasted from half an hour to one hour. These long periods are, however, unusual.

The oviposition tunnel is circular and in diameter measures slightly more than the greatest diameter of the egg, leaving ample room for the swelling of the egg when the young larva develops. The oviposition tunnel penetrates the wood either at right angles to the longitudinal axis of the stem, or at a slant, and it varies in depth from 6–7 mm. up to 18–20 mm. The oviposition holes are easy to locate with a little practice, even on the bark, for some time after the insect has departed. Plate ix shows the location of a number of such holes ringed round with white paint on a larch at Tubney, which was frequented by the adults. The oviposition holes on this tree were legion, and further reference to their density is made elsewhere. In the case of fresh trees it is still easier to locate the oviposition holes on the wood surface by removing the bark, when each hole can be seen surrounded by an area of discoloured tissue, which is due to the necrosis of the cells in its immediate vicinity. It was formerly believed that only one egg was deposited in each tunnel, but Scheidter recently showed in the case of *S. gigas* that this was not always the case. He figures one tunnel of this species which has had 6 eggs deposited in it. I have also found with *S. cyaneus* that one egg to a tunnel is the exception rather than the rule. Three to four eggs to a tunnel is quite a common number, and in some cases I have found as many as six or seven.

The total capacity of egg-laying varies considerably in different species. Scheidter, for example, found by dissection of the ovaries in *S. augur* an average of over 1,000 eggs, whereas in *S. noctilio* the average was only 400. Dissection of the egg tubes in large females of *S. cyaneus* taken at Tubney in September 1926 gave 300–400 on the average.

It is a common occurrence to find adults that have died while egg laying still fixed to the tree with the ovipositor buried in the wood. Two reasons can be assigned for this : First, the insect often chooses a place for oviposition where the sap flow is too strong, with the result that once the ovipositor is inserted she is unable to withdraw it, the moist condition of the wood causing the fibres to close in and hold it fast. Three or four dissections of adults that were found in this position were made during the summer, and in all cases the state of the egg tube showed that oviposition was at its height. Secondly, however, it is possible that some of the insects that were caught in this manner are those which, having come to an end of their egg-laying, are exhausted by their labours and thus perish in the completion of their task.

The egg (fig. 7) in both species is fusiform and translucent. It measures 1·25 to 1·5 mm. in length, is markedly constricted at one end and rather broadly rounded at the other. No definite pattern can be traced on the surface of the chorion. The eggs are deposited right up to the tunnel opening.

The incubation period is, so far as I have been able to calculate from my observations this summer (1927), 3 to 4 weeks. The young larva is completely developed before it leaves the egg (fig. 7), out of which it bites its way with the mandibles.

The first young larva found this summer on 29th August had already begun boring its own tunnel This larva measured 2 mm. in length and was one of the earliest hatched of the season, as three days later, on 1st September more young larvae were found which were still lying in the oviposition tunnel, not having begun to bore on their own account. Eggs were found up to 22nd October, and young larvae just leaving their egg-shells up to 8th November. The height of the oviposition period I take to be from the middle of August to the middle of September, and calculating 4 weeks as a maximum for the incubation period, I conclude that young larvae should still be found in the oviposition tunnels until early in November. The records which have been taken agree very closely with this estimate. On dissecting some oviposition tunnels of *S. cyaneus* recently (February 1928), two larvae were found lying in them not yet free from their egg-shells. This indicates that in the case of eggs laid late in the season, the incubation period may be much longer than usual. I have found only two cases of this so far.

The young Larva.

The morphology of the mature larva of *S. gigas* and *S. juvencus* has been described by Ratzeburg, Hartig, Cameron and others, and Yuasa, in his " Classification of the

Fig. 7. *S. cyaneus:* egg with young larva *in situ*, ×60.

Larvae of the Tenthredinoidea," has described the larva of *Tremex columba*, Jurine, as a type of the family. The following notes refer to the first larval stage of *S. cyaneus* found in the oviposition tunnels at Tubney.

The first stage larva still under the cover of the eggshell is pale white and translucent, only the strongly chitinous mandibles and terminal spine showing dark brown in colour. The larva on hatching measures 1–25 mm. in length and has a uniformly cylindrical body which tapers somewhat towards the anal end. The body surface, examined superficially, appears smooth and shining, but on closer examination it is found to be covered with minute spines which are placed in regular rows on every segment. These spines, which hardly rise above the surface of the integument, do not seem sufficiently well developed to afford the larva much aid in locomotion. The head, which (as in the later stages) is markedly overhung by the prothoracic segment, is dome-shaped, smooth and shining, and directed ventrally.

The antennae (fig. 8, *b*), which are apparently two-jointed, have a truncate terminal joint armed with a number of blunt spines. In the mature larva the antennae are three-jointed and have their terminal joint markedly pointed. The mouth-parts (fig. 8) are well developed and exhibit the following characters: The

labrum (*a*) is markedly asymmetrical, a characteristic which is developed to an even greater degree in the later stages. On its front margin there are several rows of spinous processes, giving it a markedly roughened appearance. This is in contrast to the labrum of the mature larva in which the front margin is entire and heavily chitinized. The two mandibles also differ markedly from one another; the right mandible (*d*), which lies above the left when at rest, is somewhat quadrate in shape and bears a large lobe on its inner side and four blunt teeth on its outer margin; in the left mandible (*c*) the inner lobe is much less strongly developed and the outer margin is provided with only three teeth.

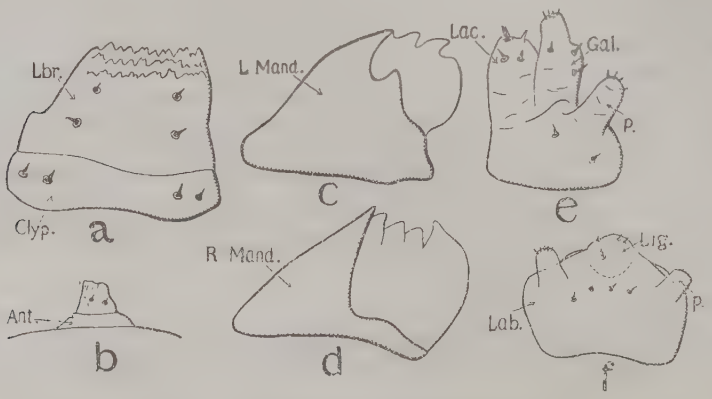


Fig. 8. *S. cyaneus:* mouth-parts and antenna of young larva, × 225.

The maxillae (*e*) are fleshy, the palpi one-jointed and conical, bearing a number of blunt setae at the tip. The galea is broad at the base and markedly constricted at the tip, on which there are a number of spines. The lacinia is more dome-shaped and bears at least three well-marked spines at the tip. The labium (*f*) is soft and fleshy with well marked single-jointed palpi. The ligula is circular and fits closely into the deep emargination of the mentum. Mamma-like thoracic legs are already well developed, and each bears a prominent terminal spine. The spiracles number nine pairs, of which the prothoracic pair are much larger than the rest. They are markedly circular in form and in this respect differ from the later stages, in which they are oval. The terminal abdominal segment is hollowed out in a deep depression on the tergum, at the apex of which are borne two short blunt tubercles. Beyond these lies the chitinous terminal spine, which in the first stage larva is markedly shorter than in the later stages.

The function of the terminal spine has always been considered to be concerned with the packing of the boring dust by the larva in its tunnel. After watching several larvae working in their burrows I have come to the conclusion that it also serves the larva as a terminal support, being driven into the sides of the tunnel for this purpose.

The young larva constructs its tunnel at right angles to the oviposition tunnel and continues to bore in this direction for a short distance before it turns inwards towards the heartwood. Many studies were made of these tunnels and text-fig. 9 shows some typical examples that were drawn as they appeared on 27th–29th September 1927.

Figure 9, *a* shows a sloping egg tunnel at the commencement of which, just below the wood surface, a larva has hatched, and is commencing to bore along the sap wood. In figure *b* the tunnel is vertical, and contains three larvae, all of which have begun

their tunnels ; and in figures *c* and *d* some newly hatched larvae are seen still lying in the oviposition tunnel, only one having begun to bore. All these figures are drawn from freshly dissected specimens and represent the varying conditions which one may expect to find in the oviposition tunnels during September and October. The study of the oviposition and young larval tunnels has been found to be of great importance in the study of the Cynipid *Ibalia*, and will be referred to again in the paper on that parasite.

The larva tunnels in the outer sapwood for the first part of its life. When it has grown to a length of 8–9 mm. it turns inwards towards the heartwood, usually following a more or less vertical direction, either upwards or downwards. As it proceeds on its way the tunnel behind is closely packed with frass, and at intervals in this the cast larval skins are to be found tightly wedged between the frass layers. Moulting begins very early in larval life, the first moult in two cases being found in

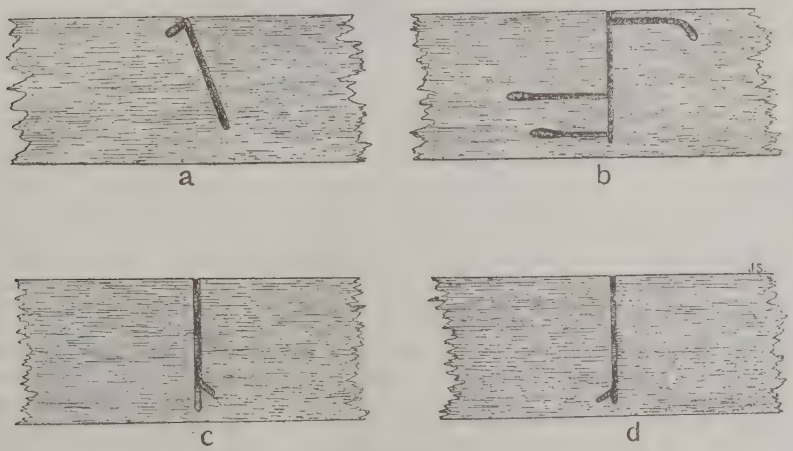


Fig. 9. *S. cyaneus:* oviposition tunnels and young larval galleries.

the frass of the oviposition tunnel itself ; and in another instance the indications were that, in the early stages at least, moulting occurs at short intervals. Recent examinations of the tunnels of very young larvae have shown that 3–4 moults take place at intervals of 1·8 mm. between each.

Direction and Length of the Larval Tunnels.

Generally speaking, the larva tunnels right to the heartwood and then curves round, returning towards the wood surface in preparation for pupation and the emergence of the adult. The variation in direction of the tunnel is, however, considerable, according to the nature of the wood. Thus larvae of *S. gigas* working in silver fir wood that was rough and knotty were often found coming up quite close to the surface in the course of their borings, in order, apparently, to avoid passing through a knotty area, the tunnel subsequently returning to the heartwood. It is, on the other hand, surprising how often one finds the larvae boring through the hardest wood. The larvae of *S. cyaneus*, when present in badly cankered larch stems, often pass straight through the worst cankered places, where the wood is very hard and resinous and consequently difficult to penetrate. Usually, however, such places are avoided, the direction of the tunnel often being abruptly altered so as to skirt around the outside of the cankered area. There are many records in the literature of *Sirex* adults

boring through coverings of lead sheeting, sometimes of considerable thickness. While this is certainly remarkable when one considers the unfamiliar nature of the medium through which the insect finds its way, the actual difficulty of boring through lead cannot, one imagines, be very much greater than that experienced by the larvae in hard and resinous wood.

Hartig records that he has found tunnels of *S. juvencus* 2–2½ feet long. The longest tunnels I have any records of are those of *S. gigas* in silver fir from South Molton, North Devon, which were measured by Mr. H. S. Hanson and reached a length of only 15 inches. In a larch log of 7 inches diameter, from which some quite large specimens of *S. cyaneus* had emerged, seven tunnels were dissected out and measured, giving the following results : 6·2, 6·8, 8·4, 8·7, 10, 10·2, 10·1 inches ; while in another log only 4 inches in diameter one tunnel totalled 8 inches ; 10 inches to 1 foot is a fair estimate of the maximum length of the tunnels of *S. cyaneus* in larch at Tubney. The tunnels of *S. gigas* are probably longer on the average ; certainly on the basis of a few specimens it would appear so, but the data on this point are at present insufficient.

Pupation.

J. H. Fabre, in an essay entitled " The Problem of the Sirex," has described how in *S. augur* the larva, when full-grown, lies lengthwise in the tree not far from the centre of the trunk. In this position metamorphosis takes place and the adult insect, on emerging, is faced with the problem of cutting its way out through the wood in which it lies a prisoner. In the vertical plane in which it lies this is a difficult task for the heavily armoured adult, which is incapable of bending the body freely. The task is accomplished, according to Fabre, by the construction of an exit gallery which is the wide arc of a circle, whose lower extremity is connected with the larval tunnel, and whose upper extremity is prolonged in a straight line, which ends at the surface with a perpendicular or slightly oblique incidence. The wide connecting arc, which enables the insect to adjust its position gradually, is a curve which Fabre has shown approximates as nearly as possible to the circumference of a circle, and the construction of which is a constant feature of the species even over lengths that sometimes exceed four inches. These remarkable observations by the great French naturalist have not been duplicated in the case of *S. cyaneus*. Many pupal chambers of that species have been examined, and in nearly every case the pupal cell was so constructed that the adult was afforded a perfectly straight forward passage to the outside, whether it chose to proceed in an oblique or horizontal direction. Further, with reference to Fabre's statement as to the difficulty that would be experienced by an adult turning round a sharp-angled tunnel, several pupal cells of *S. cyaneus* have been found that show the cells lying parallel to the wood surface, the exit hole being at right angles, an indication that the adults emerging from them must have been able to bend their bodies considerably in order to emerge successfully (fig. 10).

S. cyaneus pupae were found from the end of June onwards, and the depth of wood in which they lie varies considerably. The average depth is from three-quarters to half-an-inch, but in many cases, especially in male pupae, the pupal cell lies less than a quarter of an inch from the exterior. This apparent difference in the depth at which male and female pupae are found may be compared with some observations made by a Russian worker, N. K. Stark, in a recent paper on " The Distribution of the Sexes of some Longicorn Larvae in Trees." This author working on the longhorn beetles, *Callidium sanguineum*, L. and *Saperda scalaris*, L., in old oak wood, found that the larvae and pupae which occurred at different depths were not of the same sex. The females invariably occurred in the deeper galleries and fed longer than the males, which were usually superficial feeders. The author suggests that the same distribution of the sexes may apply to *Acanthocinus aedilis*, L., another longicorn borer in pine, and to *Pissodes pini*, L., a common weevil enemy of young

pine plantations. I have good reason to believe that the distribution of the pupae in *S. cyaneus* shows the same peculiarity, which, as the author suggests, is due to variation in the length of the larval tunnel.

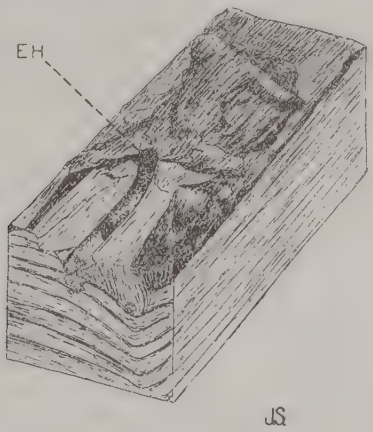


Fig. 10. *S. cyaneus:* abnormal pupal cell. EH=exit hole.

Larvae have been found ready for pupation in tunnels that were only separated from the exterior by a thin layer of bark; but such cases are unusual. Scheidter found pupae of *S. augur* 4¾ inches from the wood surface. The pupae of *S. cyaneus* when lying too deep in the wood often perish *in situ*, either in the pupal stage or as adults. For example, while examining silver fir logs for *S. gigas* material recently, I was struck by the numbers of adults that were found dead in their tunnels, sometimes in the pupal chamber, sometimes on their way to the outside. These adults were nearly always covered with fungus, but whether this fungus was the cause of death or an after-growth, I do not know; but I imagine that the death of the pupae and likewise that of the adult is due to some organism whose attack is induced by change of moisture conditions in the wood. The duration of the pupal stage in *S. cyaneus* varies from 5–6 weeks.

Length of the Life-cycle in Siricidae.

The minimum period estimated by most writers for the Siricid life-cycle is two years, and with this my observations on *S. cyaneus* agree. Estimating the average duration of the egg stage at 4 weeks and the pupal period at 6 weeks, this leaves 21 months for the larval stages. From observations recently made on larvae which have hatched from eggs laid in September 1927, it would appear that up to the end of the first six months of their life the larvae reach a length of only 2–4 mm. These larvae, starting to grow in the spring, probably finish up their first year one-third to half grown. At this rate of development the approximate distribution of the stages in a two-year life-cycle would be as follows:—

Year.	Month.	Stage.
1926	August–mid-September ...	Adults ovipositing
	Mid-September–October ...	Eggs; young larvae
	October–December ...	Larvae (small, 1·2 mm.)
1927	January June	Larvae (small to 1/3 grown)
	July–December	Larvae (1/3–1/2)
1928	January–July	Larvae (1/2–full grown)
	July	Pupae
	August	Adults

Study of the relative sizes of larvae found living in the same tree at different periods of the year has shown that it is always possible to find both large and small forms at one and the same time, and this certainly suggests a possible two-year cycle. To obtain an exact figure is a matter of some difficulty, as it is fairly obvious that the period must vary considerably, depending largely upon the various factors, physical and chemical, which operate both inside and outside the wood of the tree. I do not think that we may expect to find cases of extreme length of life-cycle in the SIRICIDAE, such as have been quite often recorded of the Cerambycid wood borers, whose adults have been known to emerge from wood 17, and even 40, years after it had been converted into furniture. In these cases the dry nature of the medium has prolonged a life-cycle that normally would have been completed in 3–4 years. Dry wood conditions, no doubt, do prolong the life-cycle of SIRICIDAE to some extent, and cases have been recorded of wood-wasps emerging from the wood of a building $2\frac{1}{2}$ years after its completion. Shuckard also quotes an instance of *S. cyaneus* (*duplex*) emerging from the joists of the floor of a dwelling-house that had been built over three years. Wood-wasps have also been recorded as emerging from furniture long after its completion. It is as well to remember, however, in attempting to estimate the length of life-cycle in such cases, that wood-wasps will oviposit readily in sawn timber beams or planks, and that it is possible therefore that the wood from which the insects are emerging may have been attacked somewhat later than calculation allowed for. There is, moreover, always the possibility that in the case of timber in buildings, moisture conditions may be more favourable to a slight prolongation of the life-cycle, and, further, that the insects living in a protected environment may not perish *in situ* so readily as they do when living in logs lying exposed in the open. Under natural conditions in the forest, prolonged periods are not to be expected, and in the case of *S. cyaneus* an average period of $2\frac{1}{2}$ years may be estimated, with a possible maximum of 3 years. In cases where the adults are found overwintering in the wood, this, of course, at once lengthens the cycle by at least 6–9 months, as adults found in the wood in November are not likely to emerge before June or July of the following year.

Host Trees.

Nearly all authors have attempted in the past to assign preferential host trees to each species of *Sirex*. Thus *S. noctilio* was considered to be mainly a pine insect, which sometimes attacked silver fir and very occasionally spruce. *S. gigas* was generally regarded as chiefly an enemy of spruce, but was also recorded on silver fir, pine and larch ; Borries records it as a serious enemy of 120-year-old larch in Denmark.

Leisewitz in 1898 published a list of the European SIRICIDAE, arranged according to their host trees, and shows quite clearly that no such preferential host selection really occurs in nature. Scheidter sums up the evidence on this point in the following passages : " From this discussion the main fact emerges that neither *gigas* nor *juvencus* can be said to prefer one host tree to another. They will choose that one which is peculiar to, or most abundant in, the particular district where they occur . . . and therefore I do not think that we can designate these species as monophagous, since they are bound to no one particular species of host tree." " On the other hand," he continues, " *S. gigas* and *S. augur* are attracted to the largest trees, while *noctilio* and *juvencus* prefer trees in the pole stage." This he attributes to the fact that the two first-named species, having longer ovipositors, can penetrate the thicker bark of the larger trees more easily, while the last two, with their shorter ovipositors, are more or less confined to younger trees. From an examination of records in the literature the same conclusions appear to apply to *S. gigas* and *S. cyaneus* in this country. Evans records the two species from both pine and silver fir in Scotland, and I have records of the two species in Scots pine, silver fir, larch and spruce in Devon. In Tubney Wood *S. cyaneus* is the only species breeding in larch, to which it confines itself, leaving the Scots pine untouched. Adults of *S. gigas* were sometimes found

during the flight season in and around the wood, but it was ascertained that they were breeding in some old spruce and silver fir trees about half a mile distant. I have not found *S. gigas* averse from attacking young stems in the pole stage, having seen it ovipositing in larch poles at Tubney and also in Devon. I think, however, that there is something to be said in favour of its preference for older trees, though one might remark at the same time that *S. cyaneus* also appears to be quite capable of attacking these. The size of tree attacked may, in some cases, be no guide at all. *S. cyaneus*, for instance, is often found in the tops of larch trees not more than 3 inches in diameter.

Variation in Size of Adults.

Great variation was found in the size of the adults of *S. cyaneus* both bred from larch in cages and also taken in the open at Tubney. This phenomenon is well known in the SIRICIDAE, and Bischoff (Biologie der Hymenopteren, p. 22) alludes to it in the following passage: "In the phytophagous forms, the wood-boring SIRICIDAE are especially notable for the extreme variability in size that they exhibit, a characteristic which they share with many other wood-boring insects, and which in the case of the dwarf forms must be due to poor nourishment. In close relationship with the development of the host larvae, stands also that of the parasites, a phenomenon that is especially noticeable in those members of such groups as the PIMPLINAE which parasitise wood-borers." Evans refers to this great variation in size of the adults and gives the following figures for *S. gigas* and *S. cyaneus* respectively :—

S. gigas—large adults (measured from the front of the head to the end of Segment 8), 38, 36, 35 mm. ; small adults, 24, 18 mm.

S. cyaneus—large adults (measured as above), 30 mm. ; small adults, 16 mm.

I have also collected some figures of the variation in size of both sexes of *S. cyaneus* taken in Tubney during the past two years. Using the same method of measurement as Mr. Evans, I got the following results :—

Sex.	*Small.*	*Large.*
Male	10 mm.	18, 20 mm.
Female	10, 13, 15 mm. ...	17, 17, 22, 22, 23, 24, 24, 24, 24, 24 mm.

I have also found that this variation in size occurs in both *Rhyssa* and *Ibalia*. It is especially noticeable in the former parasite and will be further discussed in the paper dealing with that species.

Of the general truth of the statement that variation in size is related to conditions of nourishment, there can be no serious doubt. The exact nature of these conditions is, however, most difficult to ascertain. For instance, one may breed dwarf forms of both sexes of *S. cyaneus* in logs of 8 inches diameter, as well as in those which are only 3–4 inches, and conversely large adults can be bred from quite small stems. Two factors probably come into the question: the chemical constituents of the wood at different stages of decay, and its moisture content. Of the first, little or nothing is known, and one can only suggest the possibility that when wood reaches a certain stage of decay there is not enough nourishment left of the right kind to enable the insects to attain their normal size. As regards the second factor, moisture content, this must also play some part, although it is at the moment very ill-defined. I have noticed, however, that from logs kept in cages over a long period and allowed to become too dry, very small adults of both sexes were reared. Similarly in the case of trees cut in the open, I believe that smaller trees will produce undersized adults in a shorter period than larger trees, for the reason that the drying out process is much more rapid in the one than in the other.

Dr. J. Waterston has given me the following note in respect of variation in the size of adult wood-wasps in the British Museum collection.

Sirex gigas ranges in length from 12 to 40 mm. according to Enslin. The British Museum, however, possesses a magnificent ♀ of 51 mm. with an expanse of 68 mm. An average-sized female (expanse 50 mm.) is 38 mm. long. A male with the same expanse is somewhat shorter (32 mm.).

S. noctilio is only a little inferior to *S. gigas* in size. The body of the female is relatively slightly shorter. The largest examples in the British Museum measure : ♂, length 34 mm., expanse 58 mm. ; ♀, length 38 mm., expanse 56 mm.

In *S. cyaneus* the body of the female is longer than in *S. noctilio* : ♂, length 31 mm., expanse 51 mm. ; ♀, length 43 mm., expanse 56 mm.

No large examples of *S. juvencus* have been examined. The measurements of the largest ♀ are, length 26 mm., expanse 40 mm.

The Forest Relations of the Siricidae.

One of the most fundamental principles that research in forest entomology, especially during recent years, has laid down, is that for the proper understanding of the biology of an insect something more than a mere catalogue of entomological data is required. It is now realised that the insect *per se* is only one factor in the vast biological complex of the forest, and that if we would really understand its biology and seek to control its activities, we must take account of many factors and base our conclusions on a conception of the whole. This principle holds good in the case of *Sirex*, and I now propose to consider the problem in relation to the following questions : (*a*) do the SIRICIDAE attack healthy trees? ; and (*b*) if they do not, what are the factors concerned that render the host tree more susceptible to attack?

All Continental workers, including the earliest writers, are agreed upon one point, namely, that where wood-wasps are present trees which are in a sickly condition, from whatever cause, or which are suppressed by other trees, are liable to attack. Thus Bechstein says that subsequent to the devastation of large areas by the nun moth (*Lymantria monacha*) or bark-beetles (SCOLYTIDAE), wood-wasps may become abundant, and he quotes in support of this statement the records of such outbreaks in the Thuringerwald in 1778, 1787, 1797 and 1804. Ratzeburg also shares this view and quotes instances from Brandenburg in 1835, 1836 and 1843, and a later outbreak in East Prussia in 1850.

In all these cases the wood-wasps played a secondary rôle, causing technical damage to timber, and this we may consider as well established. The evidence on the primary status of wood-wasps as pests is, however, far from unanimous. Balzereit is one of the early workers quoted by Ratzeburg who considers that wood-wasps are sometimes primary and capable of attacking healthy trees. Of spruce, for example, he writes, "penetrated as they are by thousands of bore holes, they have the resin running down their trunks in streams on hot days and soon die as a result." Ratzeburg criticising this sentence says : " I can hardly believe that the latter (the wood-wasps) are to be considered as primary enemies, and that the flow of resin on the tree-trunks, as well as the discolouration which appears in the sapwood in the neighbourhood of the oviposition holes, is to be laid entirely to their charge . . . the cause appearing to me to be more likely due to the activity of bark-beetles in the cambial region." Ratzeburg admits, however, that when present in great numbers, it is possible that wood-wasps do attack and kill healthy trees under certain conditions.

Hartig, writing some years later, discusses the ability of *Sirex* to attack green trees in the following passage : " So much is certain, that the damage by the wood-wasp larvae does not produce such serious after-effects as do the tunnels of those beetle larvae that mine between the bark and the wood. The innermost bark layer and the sapwood region is the location of the sap flow and the place where all further stem growth occurs, so that damage to the organic tissues functioning here must exert an influence on the whole plant. In comparison with this, the damage done by

the wood-wasp larvae in the wood itself is only limited in effect and almost without any influence on the general health of the tree . . . We may conclude, therefore, that when a tree is attacked by wood-wasp larvae and dies in a short time, this tree was already sickly from another cause, which, apart from insect injury, would have ultimately caused its death."

In another place he also says that he has observed spruce trees which, although very unhealthy and attacked by wood-wasps, nevertheless continued to maintain a precarious existence for a long time. This last observation is supported by von Hagen, who found in Silesia that trees attacked over a 7-year period, while suffering considerably in loss of increment, were in no case killed outright.

These views are shared by the later writers, and Scheidter, the most recent of these, says that in the Bavarian Frankenwald the importance of wood-wasps is entirely technical, in which rôle, however, they are often serious. The American literature on SIRICIDAE contains practically no references to their forest relations. Felt mentions one species *S.* (*Urocerus*) *albicornis*, F., as attacking spruce (*Picea*), hemlock (*Tsuga*) and silver fir (*Abies*) in the eastern States and Canada, and says that while reports of considerable injuries to coniferous trees in the north-west territories have been received, comparatively little damage is usually done by the insect in the United States. I had occasion to observe this species in Eastern Canada (Ontario) during the autumn of 1919 on a visit to a stand of Balsam fir (*A. balsamea*) and made a few notes upon it during a brief stay. The area in question was quite a small one and the trees averaged 45–50 years of age. They had suffered considerably from wind damage and other troubles, fungus root rot among the number. At the time of my visit a heavy thinning was in progress, the stand having been marked as a sample plot, and there was a good deal of felled timber about in piles and also strewn singly on the ground. Large numbers of adults were flying at the time, and I endeavoured to ascertain what type of tree was most favoured by them for oviposition purposes. The choice available was considerable: green, healthy trees, vigorous as regards height growth and diameter increment; obviously sickly trees, still green but dying rapidly; and felled logs and branches, both green and dry. In the short time at my disposal, detailed observations were out of the question, but I was led to the conclusion that of the three types mentioned, the insects avoided the green and vigorous stems, but frequently attacked dying trees, not always successfully, on account of the strong resin flow in which the ovipositing adults were sometimes caught. Felled logs were most favoured of all, and it appeared likely that if fallen trees were present the insects would prefer these to standing trees in the majority of cases. It was with this idea in my mind that the experiments at Tubney Wood about to be described, were arranged.

Field Studies in Tubney Wood, Oxford.

The wood in which the field work has been carried out forms a small part of a mixed plantation of Scots pine and larch planted in about equal proportions. The area was planted in 1891–92 and the portion of wood in which observations were made is low-lying, quite a considerable part of it being very swampy. On my first visit to the wood, a superficial survey indicated this part as being the most likely to yield *Sirex* trees in numbers, so marked was the difference between the condition of the trees on it as compared with those on the drier portions.

The larch are in the pole stage and vary from 3 inches up to about 9 inches D.B.H., the average height being about 35–40 feet. The proportion of dead trees varies slightly, being greatest in the wetter parts. Apart from dead trees there are all gradations of green trees from healthy full-crowned trees to sickly poles that have less than one-fifth of their crown remaining. Through the kindness of Mr. W. R. Day, Mycologist to the Imperial Forestry Institute, I was able to make a survey of the wood in company with him to collect data on the following points: (1) the general

condition of the larch and its relation to soil conditions, silvicultural treatment, etc. ; (2) the presence of root fungi as antecedent to, or contemporary with, the *Sirex* attack.

These two points were considered apart from the insect question. During this survey the root systems of a dozen trees were examined, both standing and wind-blown stems being chosen. The first general conclusion which was arrived at was that the swampy nature of the ground over a large part of the area resulted in the tree roots being under water for many months of the year. The soil in these parts is light sand on top with stiff sandy clay below, which holds the water. The result is that the root system of the majority of the larch is extremely poor with consequent poor crown production, a state of matters that neglect of thinnings has increased. Two root fungi were looked for, *Armillaria mellea*, the honey fungus, and *Fomes annosus*. On a previous preliminary survey it was thought that one or both these fungi might be prevalent, causing primary injury. After searching both in the field and in the laboratory, however, no sign of the rhizomorphs of *A. mellea* or of the mycelium of *Fomes* could be traced. Slight indications of attempted penetration of *Armillaria* in times past were found, but nothing extensive. On the other hand extensive root rot was present, the tap-roots of many trees being completely destroyed. This was entirely due to the waterlogged condition of the soil. Further proof of bad soil conditions was shown by the lack of fresh root development in the deeper roots, most of the new rootlets coming from the superficial parts. Further, although thinnings had as a rule been entirely neglected, even where the trees had opened out naturally and had been given a chance to grow, they had remained at a standstill, a fact that can only be explained by the soil conditions, which are inhibiting proper root action and development. This cessation of growth is well shown by a study of the wood rings, and dates back for at least 10 years. A further indication of bad soil conditions was found in the number of trees suffering from larch canker (*Dasyscypha calycina*), which is a common symptom on areas of poor soil. An earlier survey gave a total of 50 per cent. of the trees as suffering from canker in some degree or other, most of the worst cases being in the wettest parts. The Scots pine, in contra distinction to the larch, is healthy, apart from a few windfalls here and there on the exposed south-western side.

Primarily then, the area is manifestly unsuitable for the larch, which is going back in health as a result. It now remains to show what part the insects play.

In the first place, it was found, more than once, that many trees which were obviously in a dying condition, that is, they had lost from a third to half their crown, showed no sign of insect damage at all. Apart from *Sirex*, the most obvious insect borer present was the larch longhorn borer (*Tetropium gabrieli*, Weise), a very common species in larch woods. *Tetropium* was found in some cases preceding *Sirex*, but quite as often the attack of the two insects coincided. Thus on 18th October 1927, a young larva of *Tetropium* was found just commencing its burrow in the bark of a tree in which *Sirex* had oviposited during the summer. *Tetropium* very often attacks trees which are half dead and have lost half their normal crown. *Sirex*, on the other hand, as a rule allows the tree to go much further before eggs are laid. I could find no sign of the presence of bark-beetles in numbers in the trees, previous to attack by *Tetropium* and *Sirex*, nor were there any signs on the needles of defoliating insects that could have played any part in bringing the trees to their present state.

During the summer, when the flight period of the *Sirex* approached, plans were made for ascertaining by experiment what type of tree would be most favoured by them for oviposition, and how far gone in decay the wood of a tree might be before it became unsuitable as a dwelling place for the larvae. The preliminary survey had shown that wood-wasp larvae were to be found in trees which were quite bare of foliage, but of which the wood, although sound, was fairly dry. It was also known, and has been observed by previous writers, that very much decayed wood is quite

unsuitable for wood-wasps. The methods now used were two in number, and included trap stems and direct observations over long periods of the selection of standing trees by the adults.

Six trap trees were selected in the first instance, three of which were wind blown trees with full-grown crowns and had their roots half buried in the ground, while of the other three, two had less than half their foliage remaining and the third was quite dead. These trees were closely watched throughout the season, and the results obtained from them brought out one point quite clearly, namely, that of the three wind-blown trees, two were evidently still much too green to attract the wood wasps for oviposition, while when placed on the third they would oviposit, but did not seem to be particularly attracted to it when left to their own devices. Of the other three, the dead tree was quite unattractive and the last two only moderately so. The adults seemed to be much more attracted to standing trees, and it was from these that the best positive records were obtained. Here again the insects were never found either upon trees with full green crowns or upon trees quite bare of foliage, the favourite type of tree being one that still retained a small part, a quarter or less, of its foliage. On such trees the insects settled and ovipositied freely, and marked preference was even shown for particular trees, one of which is shown in Plate ix. This tree was from the 19th August onwards constantly visited by wood wasps, the egg laying operations of more than 20 adults being studied on it over a period lasting until late in September. Large numbers of oviposition holes were found on this tree, and the position of a number of these was marked by placing white rings round them, which are clearly visible in the accompanying photograph. The density of the oviposition holes was considerable in places, no fewer than six being found in one square foot of bark. This density was surpassed by a later record, a photograph of which appears in Plate xi, fig. 3, showing six oviposition tunnels lying within one half inch square. All these holes contained larvae and eggs, but in many other cases trial borings that did not contain eggs were quite often found. Even so, however, the density of egg laying must have been considerable. In this connection Evans, writing of *S. cyaneus* on silver fir, records that on a stem 15 feet long by 3¼ feet diameter the total *Sirex* population, judging from the number of flight holes, must have numbered close on 500. In logs which contain large numbers of larvae it is remarkable how comparatively seldom one finds the tunnels running into one another. This does, of course, occur, and in rare cases tunnels can be found crossing each other at right angles. Trees of all sizes, ranging from 4 to 10 inches in diameter at breast height, were selected by the adults and oviposition extended from within 6 inches of the soil level up to the top.

The experiments at Tubney Wood have been supplemented by other observations, notably in North Devon, where, through the kindness of Mr. H. S. Hanson I was enabled to visit, in January 1928, a number of woods where *Sirex* occurs. Both *S. gigas* and *S. cyaneus* are plentiful in this part of the country and attack Scots pine, larch, spruce and silver fir. The best example of *Sirex* attack as a secondary pest was found in a silver fir wood near South Molton, North Devon, where trees over 40 feet high were dying in patches as a result of root rot caused by *Fomes annosus*, the *Sirex* appearing only on those trees in which the root rot was fairly well advanced. Some larch woods visited also showed that *Sirex* was a sure indicator of unfavourable conditions, although the cause of the trouble sometimes necessitated careful search. In one or two cases wind-blown trees were found attacked, but usually only after they had been down a little time. The above experiments and observations on standing trees susceptible to *Sirex* attack bring out the following points clearly :—

(1) That standing trees with full or half-green crowns are quite unsuitable for oviposition.

(2) That the tree has to be quite badly diseased before conditions favourable to *Sirex* appear.

(3) That the choice of trees suitable for oviposition is restricted and possibly lies between certain limits of moisture content which are at present unknown.

It is impossible at the moment to explain why cut logs are suitable for oviposition almost at once, while wind-blown trees, which still have their crowns and roots intact but are exposed to the drying influence of sun and wind, should be apparently unsuitable for a season at any rate. Recognition of standing trees suitable for oviposition is therefore difficult, but during this last season considerable help was obtained from a study of the Cynipid parasite (*Ibalia*) during its flight period. The females of this parasite on more than one occasion picked out fresh *Sirex* trees for us, the last time being late in October long after the *Sirex* had disappeared. The trees favoured by *Ibalia* all closely resembled one another in the state of the crown, of which only a quarter to a fifth remained.

Once the eggs are laid and the larvae have started work, they can continue to bore in the wood even when it has apparently dried out considerably, or when the tissues have become permeated with fungus mycelium. Thus I have found silver fir logs, the wood of which was full of fungus, with large numbers of *Sirex* boring in them. Once these larvae have matured, however, and the adults have emerged, such logs are no longer suitable for the raising of another generation. The logs by this time have reached a stage of decay at which the wood becomes soft and crumbly, and such conditions are quite unsuited to the young stages.

I should like at this point to refer to an important paper just published by Buchner entitled " Holznahrung und Symbiose," which may be described as an extended survey of the symbiotic relationships existing between wood-boring insects and fungous or bacterial symbionts. Most of the new work deals with the bark and wood-boring Coleoptera, but some remarkable new observations on *Sirex* are also described, and it is these that I should like to discuss here.

Buchner has found that the SIRICIDAE have living in association with them symbiotic fungi. These are carried by the adults in two pear-shaped glands lying at the base of the ovipositor, which contain countless numbers of strap-shaped *Oidia* of a Basidiomycete, which he states are conveyed at oviposition into the egg-tunnel. There, it appears, they develop, the mycelium ramifying through the surrounding tissues, and when the larva hatches the fungus-filled wood is taken into the alimentary tract. This Buchner suggests may represent a totally new variation of *Ambrosia* culture, in that the insect does not use the fungus itself as food, but depends on its containing an enzyme, which, acting upon the wood particles in the alimentary tract, brings them into a digestible form. These fungi, he says, are only found in the wood-boring SIRICIDAE, being absent in the parasitic ORYSSINI. He states that the *Oidia* are still present in the glands of dried museum specimens.

With a view to testing these conclusions an examination was made of an adult *S. cyaneus* that had been preserved in spirit for some months. After some difficulty, the glands described by Buchner were isolated and mounted, after treatment with cotton blue. They were found, as Buchner states, full of fungus bodies, which strongly resembled the *Oidia* as described and figured by him. Examination of the oviposition tunnel and the young larval tunnels was then made, and a number of sections stained in different ways were prepared. These showed quite clearly that the tissue in the immediate neighbourhood of the oviposition tunnel and young larval gallery was thoroughly permeated by the hyphae of a Basidiomycete fungus, and it was interesting to note that the hyphae were particularly dense in the region where the young larva was feeding. Buchner has not himself investigated the further developments of the fungus in the oviposition tunnel, larval gallery and surrounding wood, but concerning these he writes : " It must be that the oviposition tunnels are filled with eggs and fungus alternately and that by the time the larvae have hatched the wood in their immediate neighbourhood has been thoroughly penetrated by fungus

mycelium." The proof of this statement was found in many sections cut from the oviposition tunnels of *S. cyaneus*, and, further, in one section of an oviposition tunnel, the eggs in which had perished, the gelatinous egg-covering which lines the tunnel wall was permeated by numerous hyphae, affording clear proof that the fungus precedes the hatching of the larvae in beginning operations upon the wood.

Buchner's work has opened up a totally new line of enquiry, which should throw a flood of light upon the problem of the food requirements of wood-wasp larvae. The results of his future work will be awaited with interest, and meanwhile we also intend to investigate the question in the case of *S. cyaneus*, especially as regards the identity of the fungus itself, and its behaviour in the alimentary tract. That we have in this case, as Buchner says, an important example of symbiosis before us, there cannot, in my opinion, be much doubt.

Status of Sirex as a Forest Pest in Britain.

This can be considered from two aspects: (1) the relation of *Sirex* to the living tree; and (2) its importance as a timber pest. As regards the first of these, we must consider the *Sirex* as indicators of pathological conditions rather than as prime factors in their production. This rôle, as we have seen, they share with such longhorn wood-borers as *Tetropium* in larch woods, and they may in one sense be looked upon as beneficial, in that they call the forester's attention to the need for further enquiry into the underlying causes of ill-health. The recognition by foresters of the close connection getween the prevalence of such pests as *Sirex* and the health of a stand is one which will become increasingly important in this country as our coniferous areas, now in the young stage, approach maturity.

From the timber point of view the importance of *Sirex* has never loomed large in this country. Definite records of losses due to their work are almost non-existent. Miss Ormerod records *S. juvencus* (? *cyaneus*) as causing damage to 70-year-old silver fir in Cumberland in 1889, but in this case only some 40 trees were involved, the total loss being about £40.

It is unfortunate that no statistics are forthcoming concerning the losses in home-grown timber due to *Sirex*, as it is possible that such figures, if available, would show the wood-wasps to be more important than is generally realised. This would apply more especially to timber stored in yards and warehouses. In a recent conversation with a small timber dealer in the west country, I was informed that the proportion of logs rendered worthless as the result of *Sirex* borings was in many cases by no means negligible. This is probably quite often the case, but one has always to remember the possibility that the wood has been previously weakened by fungi, and thus rendered worthless quite apart from the work of *Sirex*.

Natural Enemies of Sirex.

Woodpeckers are said to destroy the larvae of *Sirex*. Scheidter regards them as being their principal natural enemies and cites woodpecker marks as useful indications of infestation. Evans also records that in Scotland, the Great Spotted Woodpecker, *Dendrocopus major*, L., attacks both *gigas* and *cyaneus* indiscriminately. Woodpecker work is much in evidence on the larch at Tubney and after examining many trees both here and in other localities, I have come to the conclusion that it is the larvae of the larch longhorn, feeding between the bark and wood, which they seek out, rather than those of *Sirex*. A good deal of the woodpecker work does not appear to me to penetrate sufficiently deep into the wood to capture the *Sirex* grubs.

Wishing to obtain further information on this point, I have examined some of the literature dealing with the food of woodpeckers, especially such results as are based on stomach analyses. I have selected the work of Collinge in this country, Rörig and von Vietinghoff von Riesch in Germany, and Beal in the United States. In all

cases the records of *Sirex* grubs in the stomachs of woodpeckers are conspicuous by their rarity. Collinge, for example, reports on 91 specimens, of which *D. major*, L., numbered five, *D. minor*, L., eight, and *Gecinus viridis*, L., 78. He estimates the percentage of insect food at 75, and gives a list of bark-beetles, weevils, longhorn beetles, LUCANIDAE and wood-boring Lepidoptera, but does not mention *Sirex*. The records of Von Riesch and Rörig tell practically the same story; and in the important monograph by Beal on the food of woodpeckers in the United States, which contains a mass of detail based on stomach analyses, *Sirex* grubs are never considered. That *Sirex* grubs are sometimes sought out by woodpeckers is undoubtedly true, but I do not believe that they are a primary object of search, and certainly the records quoted above would seem to support this view.

Mention has already been made of the frequency with which in certain localities one finds *Sirex* adults apparently killed by fungi while on their way out of the wood. Nothing is known, so far as I am aware, of the cause of this or whether it is sufficiently widespread to be of much importance. The insect parasites, *Rhyssa persuasoria*, L., and *Ibalia leucospoides*, Hochenw., have already been mentioned in the introduction to this paper and have been dealt with in a separate paper (Bull. Ent. Res., xix, p. 67, 1928).

Sirex in Australia and New Zealand.

The presence of *Sirex* in Australia and New Zealand has been known for a number of years. In Australia Levick reported in 1926 the occurrence of *S. gigas* imported in "white deal" from Danzig, which had been used in buildings, but states that there is no evidence that the insect has become established in Australia. The danger of its occurrence was, however, sufficiently realised by the authorities to cause them to list *Sirex* as an injurious pest under the Vegetation and Vine Diseases Act of 1915, which empowered quarantine officers to seize and burn all timber found to be infested. In New Zealand the situation is more serious. One of the steel-blue species, the exact identity of which is uncertain, although it has been provisionally determined as *S. juvencus*, has been present in that country for some years. Mr. David Miller, the Government Entomologist, who has watched its progress during the last few years, refers to its work in his recent bulletin on Forest and Timber Insects in New Zealand. He states that the original home of the insect was on the east coast of the North Island, but adds that by the year 1925 it became evident that its range had considerably extended.

The chief host tree is *Pinus radiata* (*insignis*), of which it attacks not only felled stems, but also living trees. It is also known to attack native species, having been found boring in weather boards of the New Zealand conifer rimu (*Dacrydium cupressinum*). Dr. R. J. Tillyard, of the Cawthorn Institute, Nelson, New Zealand, has also described the activities of the insect in a recent newspaper article entitled: "The Giant Horntail," which appeared in the "Nelson Evening Mail" of 9th February 1927. In this article Dr. Tillyard records his opinion that the insect was introduced into New Zealand from North America in Oregon lumber and gives two other localities, viz., Feilding and Marlborough provinces, as being infested. He regards the climatic conditions of New Zealand as being very suitable to the insect and dwells especially upon the large size which they may attain under the favourable climatic conditions of their new home. In a recent paper on the "Ancestry of the Order Hymenoptera" he discusses the feeding habits of the wood-wasps in New Zealand and states that they have taken to burrowing in the sapwood of the pine (p. 308). This cannot be regarded as a sign of any radical change in the habits of the insect, consequent upon their establishment in New Zealand. It has already been shown that in Europe and elsewhere wood-wasp larvae spend quite a considerable portion of their life burrowing in the sapwood layers. In America, he says, wood-wasps are kept in check by the severe winter conditions, and he also instances the

power exercised by the parasites *Rhyssa* and *Ibalia* in both Europe and America as a check upon their increase. Further he states that in New Zealand standing green trees are attacked quite as often as fallen stems, and advocates the establishment of mixed plantations as one means of mitigating the severity of attack.

Sufficient evidence has already been adduced to show that under European, and so far as we know American, conditions wood-wasps are not, as a rule, considered to be primary enemies, in that they do not usually attack healthy trees, and it is this aspect of the problem in New Zealand which requires the most careful study. Two possibilities suggest themselves; either that under the climatic conditions of New Zealand the insect has so changed its habits as to become a primary pest, in which case the seriousness of the problem can hardly be over-estimated; or that there is some underlying cause which predisposes the pine to their attack, the nature of which is so far unknown. Dr. Tillyard's theory that intense cold plays a considerable part in the control of *Sirex* in America is hardly tenable in view of the fact that these insects are quite as abundant in the coniferous forests of the colder regions of the continent as they are in the warmer climate of the western seaboard.

So far as the control exercised by parasites is concerned, their presence, no doubt, does act to some extent as a check on the increase of the insect to abnormal proportions. At the same time it must be realised that, parasites notwithstanding, *Sirex* play an important part in Europe and America, not as primary pests, but as members of the vast army of insects which attack fallen timber and render it unfit for structural purposes. This would certainly not be the case were the parasites as effective as Dr. Tillyard would have us believe.

While I do not wish to under-estimate the important part played by the parasites in control, for I think their introduction into New Zealand could not fail to be a very important step, yet I consider that for the complete solution of the problem attention should be directed to another aspect of the question which concerns the forester.

It is said, for instance, that the insect is attacking healthy trees. What do we understand by the term "healthy tree"? It is well known to foresters that the determination of a tree as being in perfect health is often extremely difficult, especially where exotic species are concerned. Plantations of such species often maintain an outwardly healthy appearance for a number of years, while in reality their condition may be far from satisfactory. This may be due to unsuitable soil, exposure, and similar factors, or as we have already shown, to fungus disease, the presence of which is often unsuspected until other more obvious agents of destruction follow in its wake. *Sirex*, as we have seen, is one of the commonest of these "after-effects," and therefore I would submit that one of the most urgent needs at the present time in dealing with this problem in New Zealand is a thorough study of the conditions, silvicultural and otherwise, under which *Pinus radiata* is being grown, as I feel confident that it is there that the real cause of the trouble will be found.*

Summary.

(1) A complete review of the classification and status of the Siricid wood-wasps occurring in Britain is given in this paper.

(2) The biology of *S. cyaneus*, F., which has been studied at Tubney Wood, Oxford, during the past two years, is described, together with supplementary notes on *S. gigas*, L.

* Since the above was written a paper has appeared by Mr. A. C. Clark, Christchurch College, Canterbury, New Zealand, "The Infestation of *Sirex juvencus* in Canterbury" (Te Kura Naghere, no. 2, pp. 10-16, December 1927). I received this paper too late for inclusion in my own work but it has been reviewed in the Rev. App. Ent. XVI, p. 221, 1928. Mr. Clark's work on *Sirex juvencus* is the first attempt at a thorough study of the insect in relation to forest conditions in New Zealand, and some of his conclusions bear out the truth of what has been said above to a remarkable degree.

(3) A study of the forest relations of *S. cyaneus* at Tubney has shown that this species cannot be considered a primary enemy of healthy green trees. Trees which are favoured by *Sirex* are usually markedly unhealthy from one cause or another. At Tubney unsuitable soil conditions were the principal factors.

(4) *Sirex* and *Tetropium gabrieli*, Weise, the larch longicorn beetle, may occur almost simultaneously as indicators of pathological conditions in larch woods.

(5) In North Devon *Fomes annosus*, a root fungus, was the predisposing factor in the case of silver fir attacked by *Sirex*.

(6) Both *S. cyaneus* and *S. gigas* may occur in the same tree. This was found to be the case at South Molton, North Devon, in silver fir. *S. gigas* appears to prefer larger trees, and it is not present in the larch at Tubney Wood, which is in the pole stage.

(7) The primary object of the work was to acquire a knowledge of the parasites of *Sirex*, *Rhyssa persuasoria*, L., and *Ibalia leucospoides*, Hochenw. Both parasites were studied at Tubney, and have already been dealt with (Bull. Ent. Res. xix p. 67, 1928).

(8) It is considered probable that the results obtained in the above study will throw some light on the *Sirex* problem in New Zealand. Emphasis is therefore laid upon the importance of studying the silvicultural conditions in relation to *Sirex* attack.

References.

ALTUM.—Waldbeschädigungen durch Thiere und Gegenmittel. Berlin, 1889.

ANDRÉ, Ed.—Spécies d'Hymenoptères d'Europe et d'Algérie, pp. 548–563, 1879.

BEAL, F. E. L.—Food of the Woodpeckers of the U.S.A.—U.S. Dept. Agric., Biol. Survey Bull. no. 37, pp. 1–64, 1911.

BECHSTEIN, J. M.—Forstinsektologie oder Naturgeschichte der für den Wald schädlichen und nützlichen Insekten. Gotha, 1818.

BISCHOFF.—Biologie der Hymenopteren. Berlin, 1927.

BORRIES, H.—Om Forekomst og Uidbredelse af skadelige Insekter i Danske Naaleskove.—Tidsk. for Skovbrug, xi, pp. 38–91, 1889.

BRADLEY, J. C.—Siricidae of North America.—Journ. Ent. Zool., Claremont, v, pp. 1–30, 1913.

BUCHNER, P.—Holznahrung und Symbiose. Berlin, 1928.

CAMERON, P.—Monograph of the British Phytophagous Hymenoptera, iii, pp. 130–136, 1889.

COLLINGE, W. E.—A Preliminary Report upon the Economic Status of the British Species of Woodpeckers and their relation to Forestry.—J. Bd. Agric., xxii, p. 789, 1915.

CURTIS, J.—British Entomology, vi, p. 253, 1829.

DONOVAN, E.—Natural History of British Insects, xi, p. 99, pl. 396, 1806.

DOUBLEDAY, E.—Note on Larva of *S. gigas*.—Proc. Zool. Soc. Lond. 1849, p. 95.

ENSLIN, E.—Die Blatt- und Holzwespen.—Schröder's Insekten Mitteleuropas, iii, Stuttgart, 1913.

EVANS, W.—Notes on the Wood-wasps (*Sirex*) occurring in Scotland with special reference to their present day distribution.—Scot. Nat. 1922, pp. 175–189.

FELT, E. P.—Insects of Park and Woodland Trees, ii, pp. 667–669, New York, 1905.

HARRINGTON, W. H.—Can. Ent. xxix, pp. 16–21, 1897.

HARRIS, M.—Exposition of British Insects (Martyn's Edition), p. 96, plate 28, fig. 1, London, 1792.

HARTIG, T.—Die Familien der Blatt- und Holzwespen. Berlin, 1860.

JUDEICH, J. F. & NITSCHE, H.—Forstinsektenkunde, i, pp. 672–681, Vienna, 1895.

KIRBY, W. F.—List of Hymenoptera in the British Museum, pp. 373–383, London, 1882.
KIRBY, W. & SPENCE, W.—Introduction to Entomology, p. 121, London, 1856.
LEISEWITZ, W.—Forst. Naturwiss. Zeit. München, vii, pp. 439–442.
LEVICK, J. T.—The Horntails. A Timber Pest.—J. Dept. Agric. Victoria, xxiv, pp. 463–468, 1926.
MACDOUGALL, R. S.—J. Board Agric. xiv, pp. 98–104, 1907.
MILLER, D.—Forest and Timber Insects in New Zealand.—N.Z. State Forest Serv., Bull. no. 2, 1925.
MORICE, F. D.—Help Notes towards the Determination of British Tenthredinidae. —Ent. Mon. Mag. 1904, p. 33.
ORMEROD, E. A.—Manual of Injurious Insects and Methods of Prevention, London, 1890, pp. 256–260.
PACKARD, A. S.—Fifth Rept. Ent. Commission, U.S.A., 1887.
RATZEBURG, T.—Die Forstinsekten, iii, Berlin, 1844.
RIESCH, VON VIETINGHOFF VON, A. FRHR.—Zs. angew. Ent. x, xi, 1924–1925.
RUDOW, F.—Lebenweise der Holzwespen Siricidae.—Int. Ent. Zs., iii, pp 123 et seq , 1909
SCHEIDTER, F.—Zur Lebensweise unserer Holzwespen.—Zs. Schädlingsbekämpfung, i, pp. 89–98, Berlin, 1923.
SCHMIEDKNECHT, O.—Die Hymenopteren Mitteleuropas, p. 770, Jena, 1907.
SHUCKARD, W. E.—Note on *S. duplex*.—Mag. Nat. Hist. (N.S.) i, pp. 630–632, 1837.
STARK, N. K.—The Distribution of the Sexes of some Longicorn Larvae in Trees (in Russian).—Abstract in Rev. App. Ent. xiv, p. 609, 1926.
TASCHENBERG, E. L.—Forstwirtschaftliche Insektenkunde oder Naturgeschichte der den deutschen Forstschädlichen Insekten, pp. 249–255, Leipzig, 1874.
TILLYARD, R. J.—On the Ancestry of the Order Hymenoptera.—Trans. Ent. Soc. Lond,. lxxv, pp. 307–317, December 1927.
TILLYARD, R. J.—The Giant Horntail.—Nelson Evening Mail, 9th February 1927.
WACHTL, F. A.—Die stahlblaue Fichten-, und die violette Kiefernholzwespe, *S. juvencus*, L. und *S. noctilio* Fab.—Cent. für das gesammte Forstwesen.—vii, pp. 352–359, 1881.
WESTWOOD, J. O.—Introduction to the Modern Classification of Insects, ii, pp. 114–119, London, 1840.
WYTSMAN-KONOW.—Genera Insectorum, Family Siricidae, 1905.
YUASA, H.—A Classification of the Larvae of the Tenthredinoidea.—Illinois Biol. Monographs. no. 7, pp. 319–490.

Sirex tree in Tubney Wood; a favourite haunt of the adults during August and September; the white rings indicate where females oviposited.

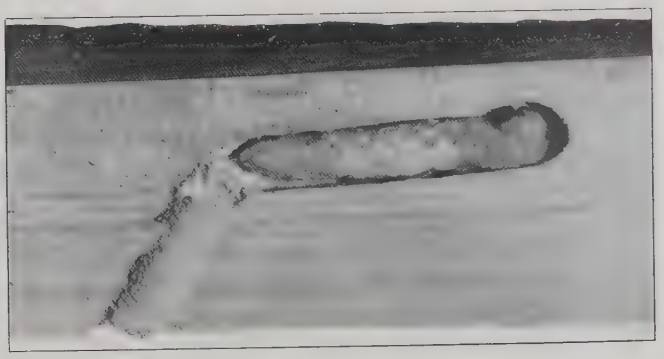
Explanation of Plate X.

Fig. 1. Pupa of *Sirex cyaneus*, Tubney Wood, July 1927. The eyes have already darkened and the last larval skin is still attached to the ovipositor sheath.

Fig. 2. *Sirex* larva in a small log of silver fir burrowing in the superficial layers of the wood, although nearly full-grown; this may occur quite often in small logs that are full of larvae.

Fig. 3. Egg of *Sirex gigas* lying in the oviposition tunnel.

1



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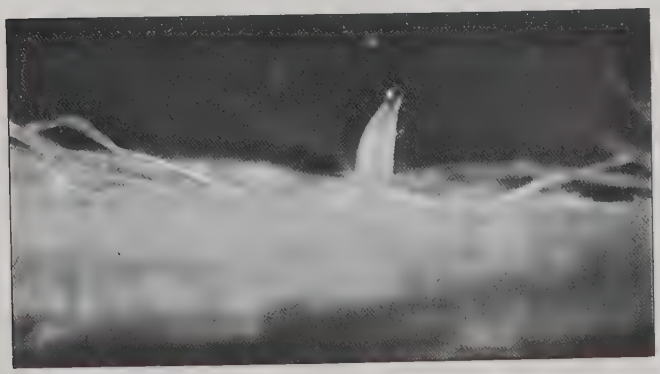

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Explanation of Plate XI.

Fig. 1. Pupal chamber of *Sirex cyaneus* in larch, showing the average depth at which it is found in the wood.

Fig. 2. Tunnels of young *Sirex* larvae in the sapwood of silver fir. The oviposition tunnel from which the two larval tunnels arise can be distinctly seen. Note also the vertical direction of the tunnels made by the larvae in the earliest stages.

Fig. 3. Inner surface of larch bark showing six oviposition holes of *S. cyaneus* within half a square inch ; each tunnel contained young larvae.

Fig. 4. Exit holes of *Sirex gigas* in silver fir. (Specimen from Mr. H. S. Hanson, North Devon.)

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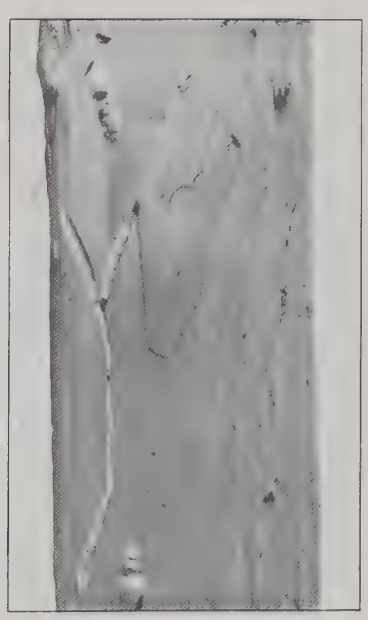

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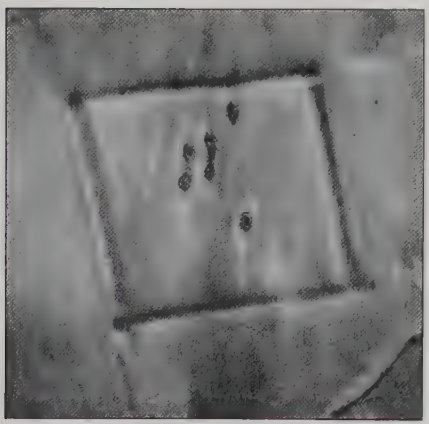

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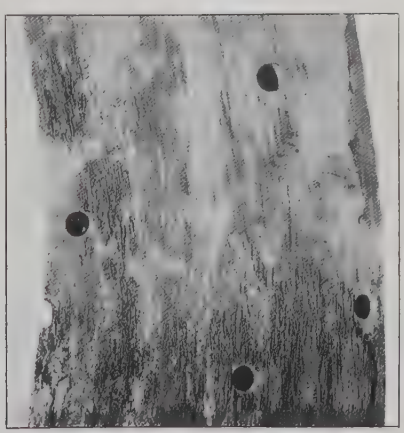

4

A NEW ENCYRTID (HYM., CHALCID.) BRED FROM *CLASTOPTERA* (HOM., CERCOP.).

By James Waterston, B.D., D.Sc.

Carabunia, gen. nov.

Head antero-posteriorly short ; occipital edge sharp ; from in front broader than long ; eyes moderate, bare ; inner orbits a little convergent ventrally ; genal space long ; face wide ; toruli high up, distinctly above the base line of eyes and only slightly below the mid point between the anterior ocellus and mouth-edge. Labrum conspicuous, simple, transverse; mandibles similar, pear-shaped, produced apically into a fine short incurved spine-like tooth. Maxillary palpi three-jointed ; labial palpi two-jointed. Inner aspect of galea and opposed side of ligula densely and finely pilose (N.B.—The first maxillary joint has an extremely narrow ill-defined annular base which may represent an obsolete joint). *Antennae* ten-jointed ; scape, pedicel, ring joint, 6 in funicle, and solid club. Scape simple, cylindrical, reaching to about level of anterior ocellus ; pedicel short ; 1st funicular longer than either the 2nd or the pedicel ; funicle (distally) and club somewhat flatly expanded ; sensoria numerous, very narrow, short and low, not produced distally. *Thorax* : mesoscutum separated from scutellum by the broadly meeting axillae, distinctly shorter (measured from its posterior edge to that of pronotum) than scutellum ; the latter ending over the metanotum in a short truncate plate ; mesopleura posteriorly truncate. Propodeon, smooth between the spiracles ; on the middle third are three linear longitudinal thickenings of the integument, the latter pair lying in shallow furrows. Round the spiracles and on the pleura the surface is densely covered with short bristles. *Wings* : forewings with apical fringe and completely pilose, except on the linea calva. Neuration to about one half. Radius emitted before the costa, long, gently curving towards and subequal to the postmarginal; two bands—one across radius, the other apical. *Legs* : mid and hind legs elongate, subequal and half longer than fore legs. Hind tibiae widened, with two unequal spurs. Tarsal ungues of all legs markedly unequal, the posterior shorter and more abruptly curved apically than the anterior. *Abdomen* broad ; 1st visible tergite (iii) about half longer than 2nd (iv), 3rd–7th gradually decreasing in length. The last three sternites densely set with short bristles. Ovipositor weakly chitinised.

♂. Antennae simple, unbranched.

The above combination of character clearly indicates a position near to *Encyrtus*.

Genotype, the following species.

Carabunia myersi, sp. nov.

♀. Body black or blackish brown with only the faintest submetallic reflections (very dark green) on the thoracic notum. The following parts are paler (yellowish to light brown) : labrum, scape (excluding the bulla) and pedicel, forelegs, mid legs (except coxae and tibial spur which are brown), hind coxae and spot at base of hind tibia. Hind femur concolorous basally with coxa but becoming darker towards apex especially dorsally. The shorter (posterior) tarsal claw blackish brown, the longer (anterior) paler. Forewings slightly tinted ; 1st band dark towards costa across postmarginal and radius, and widening but faint towards the hind edge ; 2nd band over the apical fourth and like the first darker anteriorly. Propodeon obscurely paler in middle, infuscated on pleura.

Head from in front a little wider than deep (10 : 9). Eyes over half the depth (5 : 9), genal space long, three-fifths the depth of the eye. Toruli quite above the base line of eyes, slightly below the middle of face, separated by about their own

diameter, and a diameter and a half from the orbits, the latter at level of anterior ocellus separated by two-thirds and on base line of eye by three-fifths the width. Scrobes short, L-shaped, surrounding the toruli above and separated by a short keel.

Antenna (fig. 1, *a*), length 1·58 mm. Scape just shorter than club or as long as pedicel and first two normal funicular joints. Pedicel shorter than 1st funicular; 6th funicular joint transverse. Labrum (5 : 2) with edge convex; bristles 6, 6, Stipes bare, with hardly raised large pattern. Maxillary palpi 4, 2, 5; the third

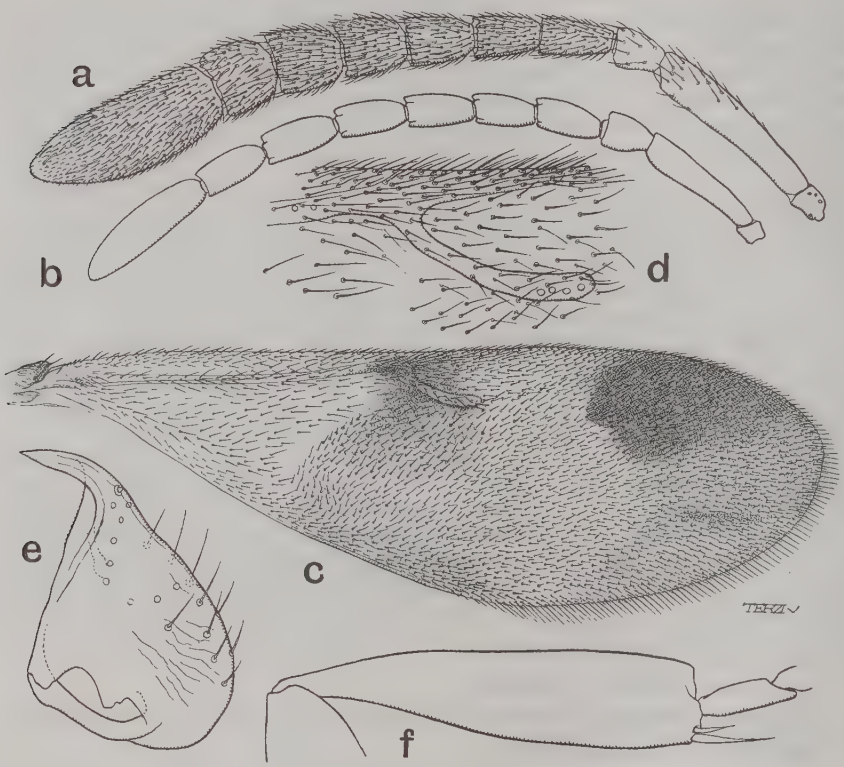

Fig. 1. *Carabunia myersi*, sp.n.: *a*, antenna of ♀; *b*, antenna of ♂; *c*, forewing of ♀; *d*, forewing of ♀, detail of radius; *e*, mandible of ♀; *f*, hind tibia of ♀.

joint thrice as long as broad and about one-fourth wider than the first, which bears one bristle; the 2nd and 3rd with 3 and about 15 respectively. Labial palpus; ratio of joints 4 : 5, 1st joint with 2 bristles, 2nd about 7.

Wings: forewings length 2 mm., over two and a half times as long as broad; submarginal : radius : postmarginal, 18 : 5 : 4. Hind wings (11 : 3) length 1·4 mm.; immediately behind the submarginella, before its uprise to the costa is a clear narrow lenticular area.

Legs. Forelegs: coxa (2 : 1) two-thirds as long as femur or four-fifths of the tibia; outer aspect with pattern coarse distinctly raised, regularly and closely set with short bristles; posteriorly smooth, about 2 short stiff bristles on anterior half. Femur

(9:2) pattern a little finer and less raised than on coxae, pile denser. Tibia (6 : 1) very densely clothed on all aspects ; comb 5 spines ; spur five-sixths of the 1st tarsal joint, which has a comb of 21–22 spines. Tarsus, 21 : 9 : 8 : 7 : 13.

Mid legs : coxa (15 : 7) half as long as femur (6 : 1), hardly half (7 : 16) the tibia, which is about 12 times as long as broad in middle ; about 10 heavy short spines at apex of tibia. Tarsus, 32 : 12 : 11 : 9 : 13, with plantar spines 12, 4, 3, 2–3, 0.

Hind legs : coxa (2 : 1) more than half (4 : 7) as long as the femur (25 : 6), which is widest at one-third from the apex or equal to half the tibia (21 : 5). Comb of about 10 spines on ventral half of apical edge ; the spurs thick basally and tapered suddenly on distal half, longer spur over half (3 : 5) the 1st tarsal joint. Tarsus, 24 : 12 : 10 : 8 : 14. The posterior tarsal claw five-sevenths the length of the anterior.

Length, about 2 mm. ; expanse, about 5 mm.

♂. Body like ♀. Scape and pedicel pale, but coxae and femora of forelegs more or less infumated. Mid femora dorsally and ventrally infuscated. Apart from the basal pale spot the hind femur is nearly as dark as the tibia. The bands of the wings nearly as pronounced as in ♀. Forewings, length about 1·6 mm. ; hind wings about 1 mm., a little broader than in ♀. Legs : general proportions and chaetotaxy as in ♀, but compared with forelegs mid and hindlegs relatively slightly shorter. In the hind leg the tibia is narrower (9 : 2). Elements of all the combs and heavier spines less numerous, e.g., fore tibia (apex) 3 ; 1st tarsal joint 13 spines. Mid leg : tibial spur as in ♀ ; tarsus, spines, 6–7 ; 2–3 ; 1 ; 1–2 ; 0. Hind tibial comb with 7–8 spines, longest spur four-fifths of the 1st tarsal joint. In all the legs the first tarsal joint is relatively shorter and the fifth longer than in ♀. Proportions of tarsal joints : fore leg, 21, 11, 9, 8, 16 ; mid leg, 32, 13, 11, 10, 16 ; hind leg, 23, 13, 12, 11, 17.

The dimensions of the ♂ are about four-fifths of the ♀.

Holotype ♀ one of a series, 4 ♂♂, 8 ♀♀, bred from nymph of *Clastoptera* sp. (Cercopidae) on *Acalypha wilkesiana*, Müll.

Cuba : Soledad, Sta.Clara Prov. (*J. G. Myers*).

Spittle-masses of the bug were sleeved 25.ii.1925, and imagines of the parasite emerged 28.ii. and 1.iii.1925, 2 ♂♂ and 4 ♀♀ on each of these dates.

Dr. Myers states that the rate of parasitism was so high that he failed to rear a single adult of the *Clastoptera*. He proposes to introduce the parasite into Trinidad in the hope that it may attack the sugar-cane froghopper (*Tomaspis saccharina*, Dist.).

A NEW SPECIES OF *DASYNUS*, BURM., INJURIOUS TO PEPPER IN JAVA (HETEROPTERA COREIDAE).

By W. E. China.

Dasynus piperis, sp. nov.

Colour.—Head irregularly punctate above, yellowish green, the tylus apically and the disc of vertex tinged with brownish yellow ; eyes dark grey, ocelli each surrounded on inner side with narrow red rim ; head below and rostrum yellow, rostral commissure and apex brownish black. Antennae dark brown, the first segment pale below, shading to black towards the apex of each segment ; extreme base of second and third segments and a broad sub-basal annulation on the fourth segment, pale yellow ; apex of fourth segment brown. Pronotum dull yellowish green, becoming deeper

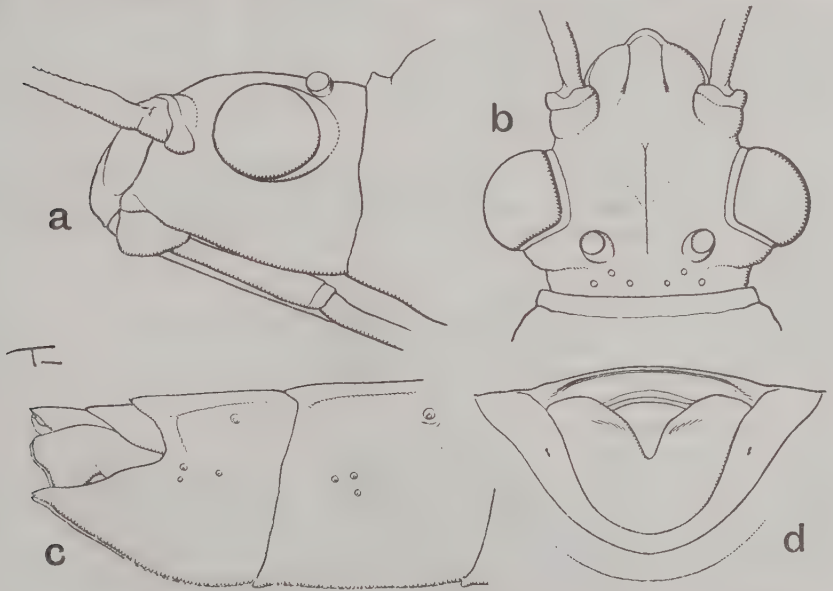

Fig. 1. *Dasynus piperis*, sp.n.: *a*, *b*, lateral and dorsal views of head; *c*, genital plates of ♀, lateral view; *d*, pygophor (segment IX) of ♂, terminal view.

posteriorly, regularly covered (except for the calli) with small but deep fuscous punctures, which are more dense along the inside of the reflexed lateral margins ; extreme humeral angles brown. Propleura yellowish green, punctate, only the outer punctures fuscous. Scutellum dull yellowish green, deeper towards apex, regularly covered with feebly infuscate deep punctures ; extreme apex yellow, impunctate. Meso- and meta-pleura yellow, tinged with green towards the basal lateral angles of the pleura, which are rugosely punctate ; sterna impunctate, sparsely covered with short erect pale hairs. Hemielytra more or less regularly punctate in series between the veins, dark brown shading to dull blood-red towards apex of corium ; veins (including costal and apical margins of corium) yellow, more or less suffused on the disc of elytra with olive-brown ; membrane black, the veins olive-brown. Legs yellow, apices of tarsi and claws brown. Abdomen yellow, sparsely covered with short pale obscure hairs.

Structure.—Body elongate ; when the hemielytra are closed their lateral margins converge gradually posteriorly. Head five-sixths as long (seen from above) as wide across eyes ; the juga swollen and completely filling space between antenniferous tubercles; tylus longer than juga, both these more or less porrect and extending well in front of the base of antennae ; ocelli about twice as far from one another as from eyes ; bucculae unarmed, short, triangular, the angle about 90°, slightly rounded ; rostrum extending to middle coxae, first segment extending beyond base of eyes, but not reaching prosternum ; relative length of segments, 38 : 35 : 21 : 26. Antennae much longer than body, very slender, first joint very long, more than twice as long as head, relative length of segments, 110 : 85 : 75 : 97. Between the third and fourth segments is a small cup-shaped false segment. Pronotum across humeral angles about 1·3 times wider than long in middle, and a little more than 2·5 times as wide as at the anterior margin ; lateral margins straight, distinctly but narrowly reflexed and very minutely and sparsely serrate ; humeral angles prominent, extending beyond the base of the costal margin, but not acutely so, the actual angle about 90°. Scutellum longer than wide at base, apex moderately acute. Hemielytra with apical margin of corium from apex of clavus to apex of corium about equal in length to the claval suture, the narrowed apical part of the corium extending to little more than half the total length of the membrane.

Legs slender, sparsely covered with short bristly hairs which are longer on the apices of tibiae and on tarsi ; femora sparsely and very minutely tuberculate, armed below with a more or less even row of short rather stout bristles arising from distinctly more pronounced small tubercles ; first tarsal segment longer than second and third together.

Male and female genitalia figured.

Size variable. Average measurements : Total length, ♂, 12·25, ♀ 13·25 mm. ; breadth across humeral angles, ♂ and ♀ 4 mm.

Java : 6 ♂♂, 2 ♀♀, Soengeilliat, 27.ii.1928 (*C. Franssen*) ; 3 ♂♂, 1 ♀, Blinjoe, 20.iv.1928 (*C. Franssen*).

Recorded by Franssen as injurious to the leaves of *Piper*.

Belongs to Stål's group *dd.* (Enum. Hemipt. iii, p. 74), and is closely allied to the Bornean species *D. shelfordi*, Bergr. 1921, from which it differs by the pale yellow bases of the second and third antennal segments, the red apical third of the corium, the absence of a percurrent longitudinal band on each side of venter, with its exterior margin provided with a series of short fuscous streaks, one in each segment. I have not seen Bergroth's species, and the above differences are taken from his description.

SOME REARED PARASITIC HYMENOPTERA FROM THE SUDAN.

By A. B. Gahan,

Bureau of Entomology, United States Department of Agriculture.

The following descriptions and notes are based upon material received from H. Bennett Johnston, Assistant Government Entomologist, Wad Medani, Sudan, Africa.

Family Braconidae.

Zelomorpha sudanensis, new species.

Very similar to (*Neophylax*) *Zelomorpha snyderi* (Ashmead) but has distinctly larger eyes and ocelli, and somewhat shorter wings with their apices more strongly infuscated and the venation darker. In *snyderi* the 2nd tergite is longer than broad, the basal and median cells are nearly as densely ciliated as the remainder of the wing and the hind tibiae are black at apex. In the new species the 2nd tergite is as broad as long, the basal and median cells are more sparsely ciliated than the rest of the wing and the hind tibiae are only slightly infuscated at apex.

Female.—Length 6·5 mm. Head a little broader than thorax, strongly transverse; vertex, temples and occiput smooth; temples very narrow; eyes very large, protruding much beyond the temples; ocelli large, separated from the eye-margin by about half the diameter of an ocellus; antennal depression smooth, margined laterally by weak carinae; face shining, obscurely rugulose-punctate, the distance from antennal depression to apex of clypeus greater than distance between the eyes; malar space very short; labrum prominent; mandibles bidentate; antennae tapering from base to apex, 42-jointed in the type, the scape very large and thick, longer than the first flagellar joint and fully twice as long as broad; first flagellar joint fully three times as long as broad, the following gradually decreasing in length, those at apex nearly quadrate; mesoscutum shining, sparsely punctate; parapsidal grooves deep, complete and very weakly crenulate; scutellum faintly rugulose, immargined except at apex; propodeum rugose, areolated, the median area spindle-shaped, extending from base to apex of propodeum and divided in the middle by the transverse carina separating posterior face of propodeum from the anterior or dorsal face; sides of pronotum smooth; mesopleura sparsely punctate, the sternauli very slightly or not at all crenulate; hind coxae rugulose above, smoother beneath; anterior tibial spur as long as the basitarsus; inner spur of middle tibia as long as the basitarsus; the inner spur of hind tibia about two-thirds as long as basitarsus; venation as in the genotype; apical half of forewing finely and densely ciliated, the basal half more sparsely so, the cilia of basal and median cells more scattered than elsewhere; abdomen as long as thorax, entirely smooth, first tergite a little more than twice as long as broad at apex, second subquadrate or a little broader than long, third subequal to the second, following tergites strongly compressed; ovipositor about as long as second tergite. Colour reddish testaceous; apex of mandibles, antennal flagellum, costa, stigma and ovipositor sheaths black; extreme apex of hind tibiae and their tarsi fuscous; apical half of forewing distinctly fuscous, the infuscation strongest along apical margin; hind wing mostly hyaline but with apical two-thirds or more of radiellan cell infuscated; venation, except costa and stigma, brownish yellow.

Male.—Ocelli smaller than in the female, the ocell-ocular line subequal to the diameter of an ocellus; eyes also somewhat less prominent; antenna 40-jointed in the allotype. Otherwise like the female.

Type-locality.—Wad Medani, Sudan, Africa.

Type.—Cat. No. 41096, U.S.N.M.

Two females (one type) and two males (one allotype) taken by H. Bennett Johnston on Leguminous crop 13.i.1927. Host unknown. One male paratype in British Museum ; remainder of type material in U.S. National Museum.

Apanteles ruficrus, (Haliday).

Seven specimens, reared from a borer (probably *Sesamia cretica*, Lederer) infesting *Pennisetum typhoideum* at Khartoum, Sudan, by H. Bennett Johnston, 2.xii.1926, agree in every way with specimens in the U.S. National Museum collection, determined as this species by T. A. Marshall.

Microbracon brevicornis, Wesmael.

Seventeen male specimens bred by H. Bennett Johnston from larvae of *Sesamia cretica*, Lederer, at Wad Medani, Sudan, 5.i.1926, have been compared with European specimens of *brevicornis* by the writer and appear to be identical.

Family Chalcididae.

Brachymeria sesamiae, new species.

The small size, blunt apex of abdomen, punctate first tergite, and mostly black femora apparently distinguish this species from any of the species already recorded from Africa.

Female.—Length 2·8 mm. Head rugose-punctate with a median longitudinal ridge below the antennae and the antennal depression smooth ; carina separating face from cheeks with a rather weak postorbital branch which extends obliquely upward and posteriorly to the occipital carina : antenna rather short, ring-joint strongly transverse, first and second flagellar joints about as broad as long, the following joints a little broader than long ; pronotum, mesoscutum, and scutellum coarsely and closely punctate ; scutellum carinately margined at apex but not emarginate ; propodeum coarsely rugose-reticulate ; hind coxae smooth above, punctate beneath, without a tubercle on inner side ; hind femora outwardly finely punctate over most of its surface but nearly smooth along the ventral margin, with ten or eleven marginal teeth, the basal tooth not much larger than the others, without an inner tooth at base; postmarginal vein about half as long as marginal and more than twice as long as stigmal ; abdomen shorter and narrower than thorax, subglobose, bluntly rounded at apex, the apical tergites retracted or curved backward toward the base of abdomen so that they become more or less ventral ; first tergite comprising more than half of the total length of abdomen, uniformly finely shagreened all over and mostly bare but with a patch of sparse whitish pubescence on each side behind the middle ; second to fifth tergites sculptured like the first and uniformly clothed with whitish pubescence except that the pubescence on the middle of the second tergite is weaker than elsewhere ; sixth tergite not visible from above, mostly ventral, about twice as broad as long, a little more coarsely sculptured than the second and pubescent ; ovipositor not visible from above. Head, thorax, abdomen, antennae, all coxae and all femora black ; tegulae, second joint of all trochanters, narrow band at apex of all femora, anterior and median tibiae entirely and all tarsi yellowish white ; hind tibiae also yellowish white behind but with a narrow blackish band at extreme base, and more or less of the sides and anterior margin black ; wings hyaline, venation brownish black.

Male.—Length 2·4 mm. Similar to the female but with the apical tergite more transverse, the hind femur with eight to ten teeth.

Type-locality.—Khartoum, Sudan, Africa.

Type.—Cat. No. 41095 U.S.N.M.

Four females (one type) and two males (one allotype) received from H. Bennett Johnston and said to have been reared from the pupa of *Sesamia cretica*, Lederer. One female and one male paratype in the British Museum; remainder of type series in U.S. National Museum.

Family Eulophidae.

Pleurotropis furvum, new species.

Runs to *amaurocoela* in the key to species of *Pleurotropis* from Africa and Persia published by James Waterston* but differs from the description of that species in that the vertex is weakly sculptured all over, the mesoscutum is very weakly and nearly uniformly reticulated and shining black, the scutellum is black, the propodeum is brassy and the first tergite is not green but black with a brassy tinge. Sculpture of mesonotum unusually weak for species of this genus.

Female.—Length 1·45 mm. Head not broader than thorax, the carina separating vertex from occiput very indistinct, the occiput less concave and not so sharply defined as usual for the genus; vertex faintly reticulated, more or less shining; frons above the transverse groove very nearly smooth and shining, below the groove distinctly finely reticulated; cheeks, temples, and face below antennae smooth; eyes with indistinct sparse short hairs; antennal pedicel as long as the first funicle joint; funicle three-jointed, the first and second joints about one and one-half times as long as thick, the third subquadrate; club conic ovate, not quite so long as two preceding funicle joints and terminating in a short weak stylus; dorsal aspect of pronotum smooth and polished, declivous anterior portion finely sculptured and opaque; mesoscutum very weakly and finely reticulated and shining, the lines not raised, the depressions at posterior margin representing the obsolete parapsidal grooves shallow and sculptured like the rest of mesoscutum; scutellum smooth down the middle, very weakly reticulated laterally, the demarcation between the sculptured and smooth areas indefinite; propodeum smooth and polished, the central and lateral keels very delicate but distinct; marginal vein extremely slender; abdomen about as long as thorax; abdominal petiole very short; second tergite comprising somewhat more than half the abdomen, nearly smooth but with some very weak shagreening; other tergites short and similarly weakly sculptured; ovipositor not exserted. Head black with faint bluish and metallic tints in some lights; antennae black, the scape and pedicel slightly metallic; pronotum black anteriorly, the dorsal aspect brassy, mesothorax black with very slight greenish or metallic tints; propodeum bright brassy; abdomen black with a slight brassy tint which is strongest at base of first tergite; legs black with greenish or metallic reflections; all tarsi pallid with the terminal joint black; wings hyaline, the venation pale.

Male.—Length 1·25 mm. Face metallic green; vertex, thorax and base of abdomen brassy; apex of abdomen black; legs metallic, their tarsi except apical joint pale. Abdominal petiole thick and as long as broad. Otherwise like the female.

Type-locality.—Khartoum, Sudan, Africa.

Type.—Cat. No. 41097, U.S.N.M.

Thirty-three females (one type) and two males (one allotype) received from H. Bennett Johnston and said to have been reared from pupa of *Sesamia cretica*, Lederer. Four paratypes in the British Museum, two returned to the collector, the others in the U.S. National Museum.

* Bull. Ent. Res., v, 1915, p. 345.

TWO SPECIES OF GALL-MITES (ERIOPHYIDAE) OF THE LILAC (*SYRINGA VULGARIS*, L.) NEW TO BRITAIN.

By A. M. Massee,
East Malling Research Station.

(Plate XII).

During 1926 and subsequently in September 1927, two species of gall-mites were found on lilac, shoots of which were obtained from private gardens at East Malling and Sevenoaks, Kent.

The damage caused by the commoner of the two mites is very characteristic, and can be recognised readily once the symptoms of the disease are known. The mite in question infests the newly developing buds, more frequently those towards the tips of the shoots, and the buds dry out completely as a result. The infested twigs become stunted and distorted (Pl. xii, fig. 1).

Although this mite has not been recorded previously in this country, it has been overlooked in all probability, since it was recorded in Europe 37 years ago by Professor Nalepa. This mite belongs to the genus *Eriophyes* and is identical with the species described as *Eriophyes löwi*, Nalepa. It has been recorded previously from Germany, Austria, Italy, and France.

The second species of mite found on lilac does not appear to be so common as *E. löwi*, Nal., and generally speaking it is more difficult to detect. This mite causes two types of damage. First, the mites live freely on the leaves, causing a yellowish-brown mottling on the upper surface. Secondly, the mites attack the unopened flowers, the developing flowers, and subsequently the fruits. In instances of severe infestation the flowers are badly malformed, and very few fruits are produced on the flower-heads (Pl. xii, fig. 2). The name of the mite is *Phyllocoptes massalongoi*, Nal.

Detailed systematic descriptions of these two species are appended, the description of *Phyllocoptes massalongoi* being copied in part from the original description of Nalepa.

Eriophyes löwi, Nal.

1890. *Phytoptus löwi*, Nalepa, SB. Ak. Wien, xcix, p. 44, pl. i, figs. 3, 4.

Body cylindrical, small. Nymphal stages worm-shaped. Thoracic shield almost quadrangular, not projecting over rostrum. Shield with longitudinal furrows at centre. Central portion otherwise smooth. Markings at lateral edges not conspicuous. Thoracic bristles situated at posterior margin of shield, placed midway between central furrow and lateral margins of shield, not widely separated. The bristles are conspicuous, directed towards anal lobe, and are slightly tapering towards apex ; 36 μ long. Warts of thoracic bristles very conspicuous.

Rostrum short, weak. Chelicera 30 μ long. Legs short, weak ; 4th and 5th joints of both pairs similar, and of equal length. Leg bristles weak. Claws of 1st pair 11 μ long. Feathered claw 4-rayed, delicate.

Sternal ledge simple, short. First and 3rd pairs of coxal bristles short ; 2nd pair in line with inner coxal angle, 20 μ long.

Abdomen marked with coarse punctate rings on dorsal and ventral surfaces, there being 60 rings, which are equidistant. Lateral bristles slender, situated in line with posterior margin of epigynium. First pair of ventral bristles 20 μ long, hair-like, 2nd pair 10 μ long, 3rd pair 20 μ long, stout, hair-like at apex. Anal lobe conspicuous, moderately well defined. Caudal bristles long, tapering, hair-like

towards apex. Accessory bristles absent. Epigynium flat, small. Coverflap marked with indistinct longitudinal lines. Genital bristles directed towards lateral margins, moderately long,

♀, 160–170 μ long, 40 μ broad ; ♂ 140 μ long, 40 μ broad.

Host-plant : *Syringa vulgaris*, L. Malformation of buds.

Distribution : East Malling and Sevenoaks, Kent.

Phyllocoptes massalongoi, Nal.

1924. *Phyllocoptes massalongoi*, Nalepa, Marcellia, pp. 94–95.

Body spindle-shaped. Thoracic shield large, triangular, 37 μ broad. Shield with indistinct longitudinal furrows. Thoracic bristles 24 μ long, situated at posterior margin. Warts large, conspicuous.

Rostrum large, gradually curved downwards, more so towards apex. Chelicerae 34–38 μ long. Legs short and weak ; 1st pair 34 μ long, 4th and 5th joints 14 μ long ; 2nd pair 29 μ long. Claws of 1st pair 7·5 μ long ; 2nd pair a little longer. Feathered claw 4-rayed, slender.

Sternal ledge simple, small. First pair of coxal bristles short and fine ; situated behind anterior margin of sternal ledge ; 2nd pair in line with inner coxal angle ; 3rd pair 30 μ long, slender.

Abdomen with 34 narrow, smooth tergites, which are closer together towards anal end of abdomen. Dorsum of ♂ almost always punctate. Some individuals with 52 tergites. Ventrites numerous. Ventral bristles all very fine. Lateral bristles 28 μ long, situated in line with anterior margin of epigynium. First pair of ventral bristles 38 μ long ; 2nd pair 18 μ long, very slender ; 3rd pair 27 μ long, hair-like. Anal lobe small. Caudal bristles 37 μ long, very slender. Accessory bristles short. Epigynium basin-shaped, 24 μ broad. Cover-flap striped, weak. Genital bristles slender, directed towards lateral margins, 20 μ long. Epiandrium blunt, 21 μ broad.

♀, 180 μ long, 56 μ broad ; ♂, 140 μ long, 48 μ broad.

Host-plant : *Syringa vulgaris*, L. Malformation of flowers and fruits ; also browning of leaves.

Distribution : East Malling and Sevenoaks, Kent.

According to Nalepa this species varies very considerably, as for example in the number and breadth of the tergites, also in the punctation on the dorsum. The length of the rostrum and the breadth of the epiandrium also vary in some specimens.

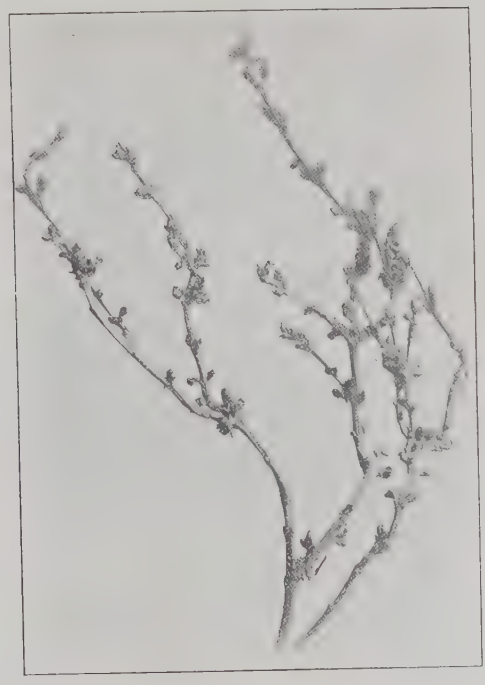

Fig. 1. Malformation of lilac buds caused by *Eriophyes löwi*, Nal.

Fig. 2. Malformation of lilac flowers and fruit caused by *Phyllocoptes massalongoi*, Nal.

NEW PARASITIC HYMENOPTERA.

By D. S. Wilkinson,
Senior Assistant, Imperial Bureau of Entomology.

Family Ichneumonidae.

Henicospilus euxoae, sp n.

♂♀. Red; thorax dark red; orbits, vertex, ocellar tubercle, almost white; wing veins very dark; costal veins and stigma yellowish red, as are often the tibiae and tarsi; abdomen somewhat darker towards apex.

♂♀. *Head*: face definitely punctate, with a small distinct tubercle in the middle just below the toruli; flagellar joints 48–50; mandibles (fig. 1, *a*) with the upper tooth much the longer; ocelli on a large distinct tubercle, almost touching the eyes. *Thorax*: mesonotum and mesopleurae with very definite and comparatively strong punctures, almost reticulate-punctate; disc of scutellum strongly laterally carinate to apex, strongly punctate (more strongly than the mesonotum); propodeon in basal third with a very definite transverse carina beyond which the integument of the propodeon is more strongly rugulose than before it. *Wings* (fig. 1, *b*) very definitely more closely haired towards the apex than basally; size, number, and position of the corneous marks, very regular; nervulus slightly variable in position, occasionally being virtually interstitial.

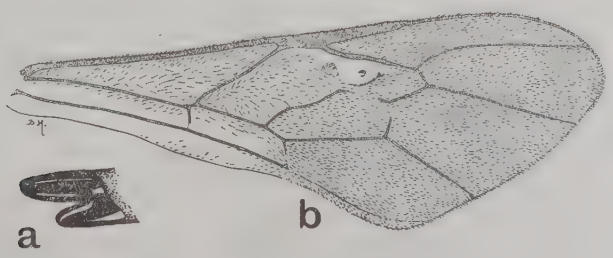

Fig. 1. *Henicospilus euxoae*, sp. n.: *a*, mandible; *b*, forewing.

Length, about 16–21 mm.

Africa: Salisbury, S. Rhodesia, 3 ♀♀, 3 ♂♂, 31.xii.1927 (*type*), 15.ii.1926, 18.ii.1926 (*J. Isgaer Roberts*).

Type deposited in the British Museum.

Host. Recorded as bred from the Noctuid, *Euxoa segetum*, Schiff.

This species may be immediately separated from *H. merdarius*, Grav., by the nature of the punctation on the mesonotum as compared with that on the mesopleurae. *H. merdarius* also has been recorded as parasitic on *E. segetum*.

Family Braconidae.

Fornicia, Brullé.

Fornicia, Brullé, Hist. Nat. Ins. Hym., iv, 1846, p. 511.

Odontofornica, Enderlein, Ent. Mitt., i, 1912, p. 260 (*syn. n.*).

The extremely interesting and aberrant genus *Fornicia* was erected by Brullé for the reception of a single specimen taken in Brazil (*F. clathrata*); and Ashmead

in 1905 added one other species from Manila (*F. annulipes*). Enderlein in 1912 described a species from two females from Formosa (*O. arata*), and, chiefly since its scutellar tooth was not divided, created for it a new genus, *Odontofornica*. I am informed by Dr. Muesebeck, to whom I am indebted for much kind assistance and advice in this matter, that *O. arata*, the type of which he has seen, does not differ generically from the species that I am describing below as new; this latter, however, despite the undivided scutellar tooth, is patently a *Fornicia*, specimens of which, taken in the genotype locality, are in the British Museum. I am therefore synonymising *Odontofornica* under *Fornicia*, and Dr. Muesebeck concurs.

Fornicia ceylonica, sp. n.

♀. Black; flagellum brown, darkening in apical half, pale to reddish in basal half below; scape, clypeus, mandibles apically, the four anterior legs (except their coxae and the middle trochanters), red to red testaceous; hind trochanters, hind femora (except at extreme apex which is black), apical third of hind tibiae, red; palpi, tibial spurs, basal third of hind tibiae, white; the apical joint of the four anterior tarsi commonly darker than the basal joints; tegulae, wing veins, stigma, reddish testaceous to brownish red, the latter decidedly brown or even sometimes blackish.

♂. Agrees with the ♀ in colour except that the flagellum is uniformly dark brown to black, and that the middle femora basally and the hind trochanters are decidedly nigrescent.

♂♀. *Head*: face punctate; clypeus separated and largely impunctate; vertex and occiput with minute and widely separated punctures; the ocellar region very slightly raised; antennae as long as or longer than the body; flagellum with 16 joints, joints 1 to about 4 cylindrical, about 5–12 dilated, the remainder tapering to apex. *Thorax*: the short pronotum not strongly toothed; mesonotum with a weak median longitudinal carina, narrowly along each side of which the integument is reticulate; the lines of the notauli indicated by broad, strongly reticulate bands, which latter together with the median line converge posteriorly and run into a strongly reticulate area that occupies the majority of the posterior third of the mesonotum; the integument above the tegulae strongly reticulate; mesonotum otherwise coriaceous with regularly spaced, sparse, indefinite punctation, save at the extreme apex narrowly across in front of the strongly crenulate basal sulcus of the scutellum where the mesonotum is unsculptured and shining; scutellum triangular, convex, strongly reticulate, shortly produced apically into a single, obliquely raised, truncated prominence or tooth, along the dorsal surface of which runs a strong median longitudinal carina, and which in profile is very thin, overhanging, but not extending beyond the apex of, the morphological metanotum; propodeon (fig. 2, *b*) impunctate, with a strong median longitudinal carina which bifurcates both in the apical and in the basal third to form at each point a small pentagonal area; costulae strong, running from the basal pentagonal area obliquely to a group of strong lateral carinae surrounding the spiracles. *Wings* much as in *Apanteles*; the recurrent equal to the apical portion of the 1st abscissa of the cubital, longer than the breadth of the stigma, virtually twice as long as the upper portion of the basal vein, this latter longer than the pigmented portion of the 2nd abscissa of the cubital; the radial rather more than one and a quarter times as long as the recurrent, about one and a half times as long as the breadth of the stigma, strongly angled with, and nearly twice as long as, the transverse cubital, with a stump at their point of junction; stigma equal to metacarp in length. *Legs*: hind coxae reticulately punctate, not quite reaching the apex of the 2nd tergite; the longer hind tibial spur about three-fifths, and the shorter spur half, the length of the basal joint of the hind tarsus. *Abdomen*: the three visible (basal) tergites (fig. 2, *c*) together about as long as the thorax, throughout their length

with strong, more or less regular, somewhat sinuous, longitudinal carinae, the interspaces with irregularly placed, short, transverse carinae ; the 1st tergite with a straight, median, longitudinal carina which bifurcates at the base, and which is noticeably stronger ; 2nd tergite with a raised median longitudinal area composed of the two median longitudinal carinae with the interspace (at least in basal half) level with the top of the carinae ; this median area extends into the median basal half of the 3rd tergite ; apex of 3rd tergite marginate and medianly excised.

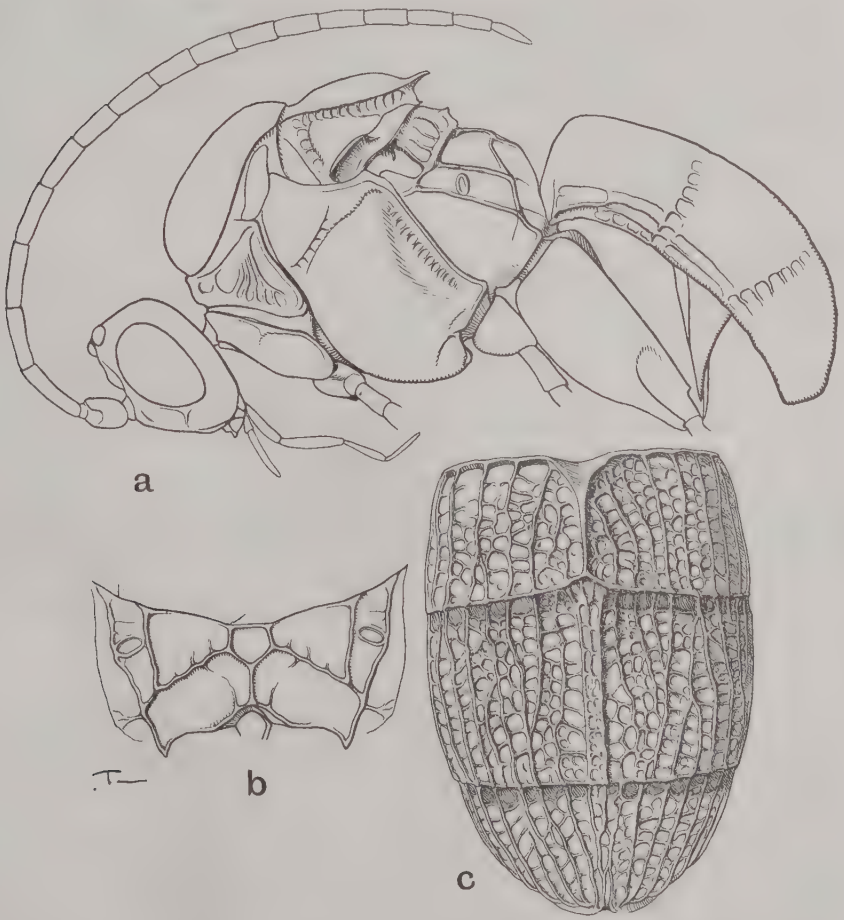

Fig. 2. *Fornicia ceylonica*, sp. n.: *a*, lateral view; *b*, propodeon; *c*, abdomen, dorsal view.

Eyes sparsely pilose ; the integument more or less throughout strongly setiferous, the setae white.

Length, about 4·5 mm. ; wing expansion, about 10·5 mm.

CEYLON : Passara, 3 ♀♀, 14.vi.1926, Madulsima, 1 ♂, 1 ♀, 10.viii.1920 (*Dr. J. C. Hutson*) ; 1 ♀, 1927 (*S. S. Light*).

Type deposited in the British Museum.

Host. Dr. Hutson's series was bred from the Limacodid moth, *Natada* (or *Susica*) *nararia*, Moore, while Mr. Light's specimen was bred from the related species *Spatulifimbria* (originally *Spatulicraspeda*) *castaneiceps*, Hmps.

There is a remarkable, large, scale-like prominence on each side of the mesonotum jutting out from the apex of the lateral faces of the scutellum and extending horizontally over the insertion of the hind wings.

This species differs notably from *F. clathrata* and *F. annulipes* in the scutellar tooth, which in these latter is divided. *F. arata*, from the descriptions, may be recognised by the colour of the antennae ; I am informed by Dr. Muesebeck, who has seen the type, that Enderlein's species is easily separable, if only by the scutellar tooth, which is decidedly emarginate, and on account of the tooth on the metanotum, which is very strong.

Cameron (1911) records *F. clathrata*, Brullé, to have been bred from a moth of the Limacodid genus *Sibine*.

Apanteles fabiae, sp. n.

♀♂. Agrees in colour with my redescription of *A. acherontiae*, except that the scape is black or strongly darkened in at least the apical half, and that the mouthparts are not red testaceous.

♂♀. Agrees in sculpture with my redescription of *A. acherontiae* except as follows : *Thorax* : punctures on the mesonotum extremely shallow and not very well separated ; disc of scutellum not more noticeably punctate in apical half ; propodeon with some scattered, weak (degree 1) punctation in basal half. *Wings* : 1st abscissa of radial shorter than breadth of stigma, equal to and usually definitely angled with the transverse cubital, rather longer than the recurrent, but this latter is apparently variable ; the upper portion of the basal vein equal to the apical portion of the 1st abscissa of the cubital, possibly rather longer than the pigmented portion of the 2nd abscissa of the cubital, in length half breadth of stigma, this latter in length equal to metacarp.

Length, 2 mm.

India : Dehra Dun, United Provinces, 10 ♀♀, 2 ♂♂, 30.x.1927 (*S. N. Chatterjee*).

Type deposited in the British Museum.

Host. Bred from a Geometrid defoliating *Fabia* sp.

Cocoons. Pupation takes place in a gregarious mass ; the cocoons are packed closely together in a pear-shaped formation and are completely surrounded by a strong closely fitting covering of silk that is almost parchment-like in texture ; the mass from which the type series was bred is constructed round a twig, and is 10 mm. long, by 7 mm. at its broadest, by 5 mm. at its greatest height.

This species is remarkably like *A. acherontiae*. An additional character of importance that can be safely used in their differentiation is the position of the toruli with reference to the apex of the clypeus and the nearest point of the eyes—in *acherontiae* the toruli are evenly placed between these two points, while in *fabiae* they are very definitely nearer the apex of the clypeus. The large, white, flocculent pupal mass of *acherontiae* is also very distinctive.

Couplet no. 14 of my key to the Indo-Australian species of *Apanteles* (Bull. Ent. Research, xix, pt. 2, p. 109), must be rewritten as follows :—

14. Median area of 2nd tergite very small and noticeably convex, at apex apparently not even as broad as apex of 1st tergite ... ... 14a.
Median area of 2nd tergite at apex as broad as or just broader than extreme breadth of 1st tergite 15

14a. Scape virtually entirely red testaceous ; 1st abscissa of radial equal to breadth of stigma, rounded with the transverse cubital ; pupae in a large flocculent mass ... ... *acherontiae*, Cam.

Scape black in apical half ; 1st abscissa of radial shorter than breadth of stigma, angled with the transverse cubital ; pupae in a small compact mass covered with almost parchment-like silk ... ... *fabiae*, sp. n.

Amicroplus tasmanicus, sp. n.

♀♂. Shining black, the legs and antennae (particularly of the females) distinctly red to red-black ; mouth-parts strongly reddened ; stigma and wing veins reddish brown, the basal fourth of the former pale.

♀♂. *Head* smooth with some minute punctation ; clypeus strongly convex and differentiated from the face by a noticeable furrow; ocelli with the posterior pair somewhat nearer to one another than to the eye ; antennae with 29–32 joints, more usually with 30 or 31 joints. *Thorax* : notauli deeply impressed and strongly crenulate, joining at a point half way along the mesonotum and thence united proceeding almost to the basal depression of the scutellum ; mesonotum otherwise unsculptured ; propodeon reticulately rugulose, dull. *Wings* : the transverse cubital in length equal to the 2nd abscissa of the radial, greater than the 1st abscissa of the radial. *Abdomen* : 1st tergite longitudinally rugulosely striate, as to some extent is the 2nd tergite at the base ; remaining tergites unsculptured and shining ; ovipositor sheaths about equal to or rather longer than the hind femora, considerably shorter than the hind tibiae.

Length, 4 mm.

TASMANIA : Longford, 12 ♀♀, 3 ♂♂, 14.ii.1928 (*G. F. Hill*).

Type deposited in the British Museum.

Host. Recorded as parasitic on *Agrotis* sp. or allied Noctuid.

Closely allied to *fuscipes*, Cam. (which is a species referable to the genus *Amicroplus* and not to *Macrocentrus*), but differing noticeably in the shape of the 2nd cubital cell. *A. tasmanicus* may easily be separated from *A. infirmus*, Nees, and *A. collaris*, Spin., by the length of the ovipositor sheaths.

NOTES ON THE FEEDING HABITS OF *HABROSYNE DERASA*, L. (LEPIDOPTERA)*

By W. Maldwyn Davies, B.Sc., Ph.D.,
University College of North Wales.

The increase and spread of such introduced plants as blackberry (*Rubus fruticosus*, L.), ragwort (*Senecio jacobaea*, L.), St. John's wort (*Hypericum perforatum*, L.) and others, now constitute a menace to agriculture in certain parts of the Empire, notably Australia and New Zealand. This situation has led the Governments of those lands to investigate all possible means of control. Chemical and mechanical methods having proved either inefficient or uneconomical for the control of noxious weeds (Tillyard)[1] other lines of attack have been resorted to. The present conditions have resulted from a disturbance in the equilibrium of the natural flora brought about by the introduction of these plants, and the solution of the problem may rest in the readjustment of the ' balance ' by the establishment, placed on a scientific basis, of certain elements of the fauna which assist in keeping these plants in check in their original environment. One of the most recent developments in economic entomology, therefore, has been the application of biological control to the problem of combating the spread of noxious weeds. This has involved the critical study of insects attacking weeds and, under the auspices of the Empire Marketing Board, the New Zealand Government and the Cawthron Institute, Nelson, research along these lines has been instigated. A short detail of this scheme has been mentioned elsewhere.[2]

The common blackberry or bramble (*Rubus fruticosus*) has proved the most rampant of introduced plants in New Zealand. According to Thompson,[3] though it was introduced at an earlier date, the first authentic record of its presence is 1864. So rapidly did it spread that in 1900 it was scheduled by the Government as a noxious weed. The extent of the infestation can be judged by a saying current on the west coast of South Island that they have only *one* blackberry bush and that is 200 miles long (Tillyard).[1]

Under the present scheme, therefore, insects which appreciably attack the blackberry are being specially considered and among the first to be studied was *Habrosyne derasa*, L. (Buff Arches Moth). *Habrosyne derasa* is too well known to need description here, and accounts of the insect will be found in the works of Barrett, Meyrick, South, Spuler, etc., in fact in practically all general works on Lepidoptera. The moth has a fairly wide geographical distribution and is recorded from Asia (West Central and Northern) and Central Europe. It is common in the British Isles, except in Scotland. Specimens, male and female, of *H. derasa* were taken by " sugaring " with molasses flavoured with amyl acetate, in Harpenden at about 10.30 p.m. on the nights of 6th, 8th, 9th and 10th July 1927. The environment was a wooded scrub hill, the scrub consisting chiefly of blackberry bushes. The moths were transferred to the Insectary at Rothamsted, encaged in a deep wooden barrel, closed above by muslin, with sprigs of blackberry in water and a sugar solution in order to supply them with nutriment.

Oviposition.

Eggs were first observed on the morning of 8th July. The position of the eggs upon the host-plant appears to be unique. They were deposited on the points of the serrated leaf-edge and on the tips of the spines. So persistent was this choice of a terminal position that in some instances a tier of eggs was observed projecting from the edge of the leaf. No previous reference to this habit of oviposition can be found, but it

* From the Entomology Dept., Rothamsted Experimental Station, Harpenden.

is interesting to note that South[5] states, regarding the closely allied species *Thyatira batis*, L., " the fluted greenish-white eggs are laid upon the edges of the bramble leaves." He figures the eggs of *T. batis* on the blackberry leaf, and it would seem that they are not restricted to the mere points around the edge as is the case with those of *H. derasa*.

The eggs shortly after oviposition are easily detected owing to their whitish colour (they, like those of *batis*, are fluted longitudinally), but in a day or so this colour changes to a pinkish red and this, blending as it does with the tips of the thorns and leaves, renders detection difficult.

The incubation period averaged 16 days. After hatching the larvae crawled away, suspended themselves by silken threads from the underside of the leaf and remained in this position throughout the day. At dusk they returned to the leaf and commenced feeding.

Host-Plants.

The normal host-plant of the larvae of *H. derasa* is the blackberry. Barrett,[7] however, records the occasional presence of the larvae on hawthorn (*Crataegus oxycantha*, L.) and hazel (*Corylus avellana*, L.), and Theobald[8] includes this species under the heading " insects injurious to Raspberry (*Rubus idaeus*, L.)," but adds that it does no harm.

Feeding Tests on Economic Plants.

An insect to be of value in the biological control of noxious weeds must be specific in its feeding habits, or, at least, unable to attack any plant of economic importance. Hence it was necessary to discover whether larvae of *H. derasa* could feed and thrive on economic plants related to the blackberry. The plants used in these tests were : Blackberry (as control), loganberry, raspberry, rose, apple, cherry, plum, pear, and also currant.

The technique for these tests has been already described ;[2] briefly, it consists of isolating the insects to be tested on sprigs of the tested plant and making daily observations and notes regarding their progress. In the present instance, ten larvae were placed in each experimental cage and the tests were duplicated. Approximately the same amount of leaf area was used in each cage. A stock of larvae was kept on blackberry and these were used in the second and third sets of experiments when they were ten and twenty days old respectively. The tests were carried out simultaneously and were commenced on 26th July.

Blackberry. The twenty newly hatched larvae placed upon the blackberry sprigs were found to have fed during the first night. Although damage to the leaves was witnessed it was not until 3rd August that actual perforation of the leaves had taken place. It was necessary to replenish the food on 8th August. Feeding continued until 1st September, when the larvae commenced to bury themselves beneath the peat moss at the bottom of the cage and prepared for pupation. All had pupated at the end of the experiment (9th September).

Loganberry. The twenty newly hatched larvae were placed on sprigs of loganberry and they fed the first night, actual perforation being observed on 28th July. Food was first replenished on 6th August. The larvae continued to feed and grow normally and rapidly and larvae of the same age fed on loganberry exceeded in size those fed on blackberry. Their ability to thrive on loganberry was emphasised by the fact that pupation occurred on the average two days earlier in the loganberry cages than in those containing blackberry (29th August–6th September.)

Raspberry. Twenty newly hatched larvae placed on sprigs of raspberry also fed during the first night and perforation of the leaves was observed on 28th July. Food

was replenished on 8th August. Feeding and development were normal, and the larvae commenced pupation at the same time as did those in the blackberry cages. All larvae had pupated by 9th September.

Rose. Of the twenty newly hatched larvae on the sprigs of rose nineteen were dead on examination on 3rd August. The one larva alive appeared to be normal, but much smaller than those in the previous experiments; it, however, continued to feed slowly and finally pupated normally on 19th September.

A second series of experiments was set up on 3rd August, and in this ten larvae, 10 days old, having fed until then on the normal host (blackberry), were transferred to a sprig of rose. No damage was noted after the first night on their new host, but on 8th August, an appreciable portion of the rose had been eaten. The larvae continued to feed slowly until 17th September, when they entered the peat moss and pupated. Eight larvae pupated.

Apple. The twenty newly hatched larvae placed on apple would not settle and feed, although slight damage due to feeding was noticed on 1st August. On 5th August, however, all the larvae were dead.

A second experiment was set up on 5th August, when ten larvae, 10 days old, having previously fed on blackberry, were placed on a sprig of apple. These larvae fed upon their new host the first night. Feeding and development were slow and only four succeeded in pupating. These formed normal pupae.

Cherry. The twenty newly hatched larvae failed to survive on the cherry; all larvae being dead on 3rd August. The same day a further experiment was set up consisting of ten 10-day-old, blackberry-fed larvae on a sprig of cherry. These fed very slowly for a day or so, but on 20th August all were dead.

A further batch of ten 20-day-old, blackberry-fed larvae were placed on cherry on 26th August. Again slight feeding was detected but on 7th September all larvae were dead.

Plum. The twenty newly hatched larvae did not survive on plum, though slight damage to the leaves was evident. Ten 10-day-old, blackberry-fed larvae placed on plum on 8th August fed very slowly, and only four larvae were alive on 20th August. On 1st September one larva was alive, but this was dead on 15th September. No 20-day-old, blackberry-fed larvae were available for a further test.

Pear. The twenty newly hatched larvae did not survive on pear. Ten 10-day-old, blackberry-fed larvae commenced feeding on their new host-plant but all had died within 20 days after they had been placed on this plant.

Currant. Both newly hatched, and 10-day-old, blackberry-fed larvae failed to damage currant and soon succumbed.

Tests with a Choice of Food-Plants.

Two cages were set up containing sprigs of each of the above mentioned plants. Twenty newly hatched larvae were placed in each cage. On examination the following day the larvae were distributed among the sprigs of blackberry, loganberry and raspberry. Severe damage to these sprigs was apparent 5 days later. Similar results were obtained when older, blackberry-fed larvae were used. No evidence of attack on the other plants was secured.

Conclusions.

From the above experiments it is evident that the larvae of *Habrosyne derasa*, the normal host of which is the blackberry, will, under the conditions of these tests, feed equally well on loganberry and raspberry. Under conditions where a choice of these three plants is given they feed indiscriminately on them. Hence it appears

undesirable that *derasa* larvae should be further considered from the point of view of the control of blackberry in New Zealand. This conclusion is further supported by the fact that under isolated conditions these larvae fed and attained the pupation stage on rose and apple, while, in addition, feeding actually took place on cherry, plum and pear.*

This work was carried out in the Entomological Department, Rothamsted Experimental Station, under the supervision of Dr. A. D. Imms, whom the writer wishes to thank for valuable advice and suggestions.

Summary.

1. Insect pests of the blackberry (*Rubus fruticosus*,L.) are being studied with a view to discovering insects likely to assist in the biological control of this noxious plant in New Zealand. *Habrosyne derasa*, L., was the first species brought under observation.

2. Investigations revealed an apparently unique method of oviposition, the eggs of *H. derasa* being deposited on the points of the serrated leaf-edges of the blackberry.

3. Newly hatched larvae of this moth have been simultaneously tested as to their ability to feed and thrive on the following plants :—Blackberry (normal host), loganberry, raspberry, rose, apple, cherry, plum, pear, and currant. They thrived equally well on the first three plants. Ten-day-old, blackberry-fed larvae, when transferred to rose and apple, fed and some ultimately pupated. Similar larvae transferred to cherry, plum and pear fed sparingly but did not succeed in pupating.

4. When a choice of food-plants was given, feeding was concentrated on blackberry, loganberry and raspberry.

Literature.

1. Tillyard, R. J. (1926). "The Progress of Economic Entomology."—J. Roy. Soc. Arts., lxxv, pp. 2–20, Nov. 1926.
2. Davies, W. M. (1928). "The Bionomics of *Apion ulicis* Forst. with special reference to its rôle in the control of *Ulex europaeus* in New Zealand."—Ann. Appl. Biol. Vol.
3. Thompson, G. M. (1922). The Naturalisation of Animals and Plants in New Zealand. Camb. Univ. Press.
5. South, R. The Moths of the British Isles. Series I. London.
6. Meyrick, E. (1928). A Revised Handbook of British Lepidoptera. London.
7. Barrett, C. G. (1893–1907). Lepidoptera of the British Islands. London.
8. Theobald, F. V. (1909). Insect Pests of Fruit. Wye, Kent.

* W. J. Cross (Entom. Record ii, 1891, p. 67) records having taken larvae of *H. derasa* feeding wild upon *Spiraea ulmaria*.

OBSERVATIONS ON THE COCCIDAE OF SOUTHERN RHODESIA.—I.

By W. J. Hall, Ph.D., B.Sc., A.R.C.Sc.,

Entomologist to the British South Africa Company in Southern Rhodesia.

With the exception of a few isolated records nothing is known of the Coccidae of Southern Rhodesia. Dr. Brain has made a study of the family in the Union of South Africa, the results of which are to be found in his excellent Monograph,* and Prof. Newstead has described many interesting and hitherto unknown forms from Central Africa in the earlier volumes of this Bulletin.

One would expect the fauna—of Mashonaland and Manicaland at least—to be more closely allied to that of Central Africa, as the flora appears to bear a close affinity to that of the countries to the east and north-east, e.g., Portuguese East Africa, Tanganyika and Nyasaland.

In the short period I have been in Southern Rhodesia—just over 12 months—it has become abundantly clear that the Coccid fauna is extremely rich. Nearly 350 lots of material have been collected, representing over 100 distinct species, a surprisingly high proportion of which appear to be new to science. It must be stated here that the area collected over represents only a very small part of the country, that portion which I have to traverse in the course of my duties, i.e., parts of Mashonaland and Manicaland. All localities given, unless otherwise stated, are situated in these areas.

In view of the large amount of material collected (and being added to continually) and the limited time available for this study, it seems that it will be advisable to work out the species more or less as they are collected and to submit parts for publication as available. This will only permit of the species being very roughly grouped. In the present paper 31 species of Diaspinae are recorded, of which 17 appear to be new to science. Many other species have been taken since and will be dealt with in a later contribution.

It is intended to deposit, in due course, all types and either material or slides of all species in the British Museum (Natural History). Cotypes, wherever possible, will be given to the Department of Agriculture, Southern Rhodesia, and the Rhodesian Museum at Bulawayo.

I should like to take this opportunity of acknowledging with thanks the permission of the General Manager of the British South Africa Company in Southern Rhodesia to publish this and subsequent articles. My sincere thanks are also due to Mr. E. E. Green for his invaluable assistance in working out my material. Mr. F. Eyles, lately Botanist to the Department of Agriculture, with his extensive knowledge of the Rhodesian flora has very kindly identified my host-plants; whilst to Mr. R. W. Jack and the other members of the Entomological Department I am indebted for access to the collections and library of the Department and for material collected. Acknowledgement will be made in the text when the material has not been taken by myself.

1. Aspidiotus brachystegiae, sp. n. (fig. 1).

Puparium of adult female more or less circular and semi-transparent; colour dull brown, paler at the margin, with a reddish brown tinge in some examples. Larval exuviae yellow, with a conspicuous broad median longitudinal carina coloured deep reddish brown. Nymphal exuviae pale brown with pale reddish brown mottlings. In some specimens this reddish brown colour is much more developed than in others, giving an almost uniform colouration. The stripe on the larval exuviae, however, is

* Trans. Roy. Soc. S. Africa, v, pt. 2, 1915; and Bull. Ent. Res. ix, pts. 2 and 3; x, pt. 2; and xi, pt. 1.

always conspicuous. Secretionary covering thin and ventral scale very poorly developed, visible as a very fine white film on the host-plant when the scale is removed. Diameter 1·0–1·75 mm.

Male puparium pale brown in colour and of the usual form. Exuviae yellow, with conspicuous broad median longitudinal reddish brown stripe.

Adult female approximately circular, with antennae represented by minute tubercles, each carrying a single stout bristle. Parastigmatic glands wanting. Rudimentary thoracic tubercles occur in some specimens. Free abdominal segments with a few small, and some very minute, tubular spinnerets at the margin; the latter also occur marginally on the thoracic segments. The pygidium is triangular, rounded at the apex. Circumgenital glands in four groups—anterior laterals 7–12, posterior laterals 4–8; average of a number of examples 10 : 6. The median group is sometimes represented by a single gland, and in one case there are two glands set widely apart. Pygidium with three pairs of lobes. The median pair are large and set close together, rounded at the tip with a notch on the outer edge and

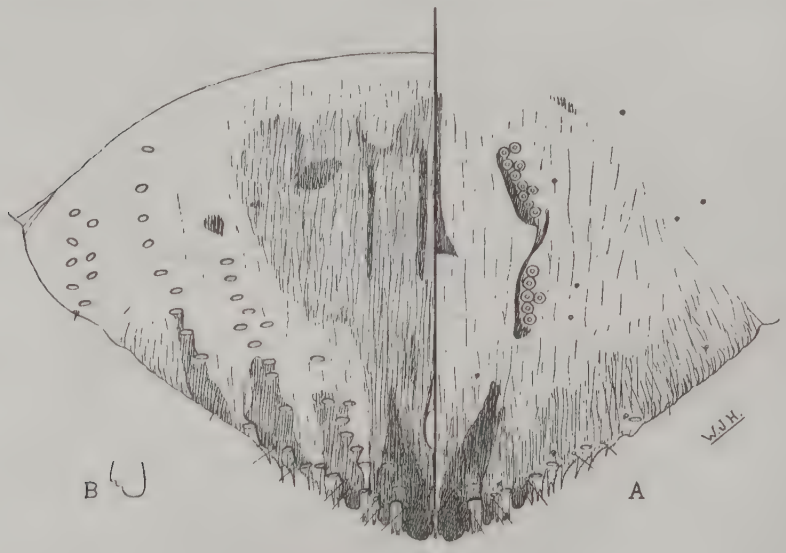

Fig. 1. *Aspidiotus brachystegiae*, sp. n.: A, pygidium of adult ♀, ×120; B, alternate form of 2nd lateral lobe.

a less conspicuous notch on the inner edge. First lateral lobe small, tending to be slender, rounded at the tip with a notch on the outer edge. Second lateral markedly stouter than the 1st lateral lobe with a deep notch on the outer edge (in some cases there are two deep notches on the outer edge). The median lobes are set so close together that it is difficult to ascertain if there are any squamae present between them. Two squamae present between the median lobe and the 1st lateral, which are of equal size and normal form; of the two squamae between the 1st and 2nd laterals that nearest the latter is the stouter of the two. There are 8 squamae beyond the 2nd lateral lobe, that nearest to it being of simple form, the next two are markedly bifid at the tip, and the remaining 5 are successively smaller, of simple form, with swollen bases. Dorsal tubular spinnerets in four obscure series running back from

between the 1st and 2nd lateral lobes, the second from the middle of the squamae beyond the 2nd lateral lobe, the third from just beyond the last squama and the last from near the base of the pygidium. Anal orifice set near the apex of the pygidium.

On *Brachystegia flagristipulata* (Leguminosae); on the smaller branches. Mazoe, 21.viii.1927.

This species may be readily recognised by the nature of the larval exuviae and the fact that the 2nd lateral lobe of the pygidium is stouter than the 1st lateral.

2. Aspidiotus combreti, sp. n. (fig. 2).

Puparium of adult female highly convex, usually circular, but crowded examples oval in outline. Exuviae more or less central; larval exuviae shiny coppery green; nymphal exuviae of similar colour but usually browner round the margin. The larval exuviae with a thin covering of white secretionary matter; frequently only a trace

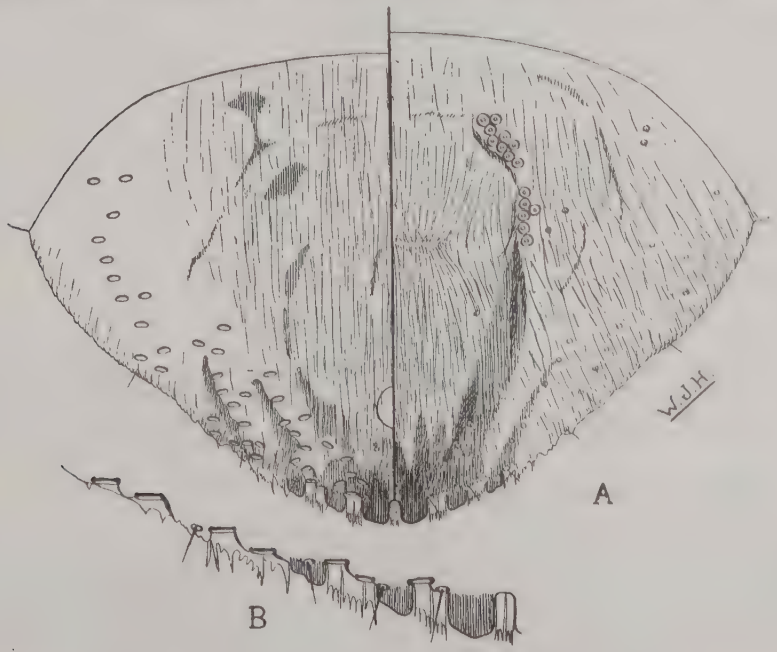

Fig. 2. *Aspidiotus combreti*, sp. n.; A, pygidium of adult ♀, ×117; B, portion of the margin of the pygidium further enlarged.

of this can be seen, the remainder having been knocked off. Nymphal exuviae with a thicker coating of white secretionary matter which obscures the colour. Secretionary area white, with very faint concentric striations. Inner surface of puparium smooth and shiny white. Ventral scale very thin, remaining adherent to the host-plant. Diameter 1·25–1·75 mm.

Male puparium not seen.

Adult female relatively large and circular in outline. Antennae represented by minute tubercles carrying each a rather long curved bristle. Parastigmatic glands wanting. Abdominal segmentation not well marked. Lateral margins of abdominal

segments with a number of scattered long tubular spinnerets. Pygidium broadly rounded, with three pairs of lobes. The median pair are dentate, separated by a space equal to half the width of one of the lobes. First lateral pair smaller, rounded, falling away on the outer edge and faintly notched. Second lateral pair slightly smaller than the first laterals, of similar shape, with the outer edge more conspicuously notched. Squamae finely fringed and only projecting slightly beyond the lobes (fig. 2, B). Anal orifice relatively large, oval, and situated near the apex of the pygidium. Dorsal pores with long tubular spinnerets, in three obscure series. Circumgenital glands present—median group 0–5, anterior laterals 5–13, posterior laterals 2–9 ; average of 15 examples 1 : 9 : 6. In 8 out of the 15 examples the median group was wanting. The circumgenital glands are very variable in number and usually set towards the base of the pygidium. The glands of the median group, if represented, usually occur in a single transverse line, and the anterior and posterior groups are not infrequently fused.

On *Combretum apiculatum* and *Combretum* spp. (Combretaceae) ; on the smaller branches and occasionally a few individuals on the leaves. Mazoe, on various dates in October and November 1927.

I know of no species that resembles this at all closely. It appears to be not uncommon on the many species of *Combretum* found in the Mazoe district.

3. Aspidiotus hederae, Vall.

Some *Melia azedarach* (Meliaceae) trees in the Municipal Garden, Salisbury, were found to be heavily infested with this species, 23.xi.1927. *A. lataniae*, Sign., was also found on the same trees.

4. Aspidiotus lataniae, Sign.

A common species in Southern Rhodesia and apparently widely distributed. It has been taken, so far, on the following host-plants :

Apocynaceae : *Plumeria* sp., *Thevetia nerifolia* ; Coniferae : *Cupressus lusitanicus* ; Convolvulaceae : *Astrochlaena malvacea* (partly aerial and partly subterranean) ; Ebenaceae : *Royena pallens* ; Leguminosae : *Acacia decurrens*, *A.* spp., *Erythrina tomentosa*, *Parkinsonia* sp. ; Meliaceae : *Melia azedarach* ; Rosaceae : *Rosa* sp.

5. Aspidiotus (Hemiberlesea) rhodesiensis, sp. n. (fig. 3).

Puparium of adult female highly convex and usually circular, except where the scales are crowded. Exuviae central ; larval exuviae dark shiny brown green ; nymphal exuviae browner and paler, at least marginally, and covered with a film of white secretionary matter. This film is sufficiently thick to obscure the colour of the nymphal exuviae, which is discernible as a slightly darkened area ; it extends over the larval exuviae also but is generally broken away to a greater or lesser degree. Secretionary area white, often with small particles of foreign matter adherent. Ventral scale very thin, remaining adherent to the host-plant. Diameter 1–1·25 mm.

Male puparium of usual form. Exuviae yellow, with a dark brown medio-dorsal stripe. In some examples this is poorly developed, in others it is developed to such an extent that the yellow colouration is only discernible round the margin.

Adult female circular in outline. Antennal tubercles minute, each carrying a long curved bristle. Parastigmatic glands wanting. Margin of free abdominal segments with scattered groups of long and short tubular spinnerets, the former being more numerous on the posterior segments and of much larger size than the latter. A few scattered short tubular spinnerets occur marginally on the thoracic segments. Pygidium broadly rounded with three pairs of lobes. The median pair more or less quadrate falling away somewhat towards the outer edge and set close together. In

old examples the lobes are often notched or worn. Lateral lobes small, not so highly chitinized as the median pair and consequently not very conspicuous. First lateral pair much smaller than the median lobes, rounded, with a conspicuous notch in the outer edge. Second lateral pair slightly shorter than the first pair but broader at the base and of similar shape. Squamae deeply fringed and only projecting a little way beyond the lobes ; it is difficult to get a preparation that shows these well. Anal orifice elongate, situated near the apex of the pygidium. Dorsal pores with long tubular spinnerets, in three obscure series. Circumgenital glands absent.

On *Brachystegia flagristipulata*, *Brachystegia* spp., *Berlinia globiflora* (Leguminosae), and *Parinarium mobola* (Rosaceae) ; on the smaller branches.

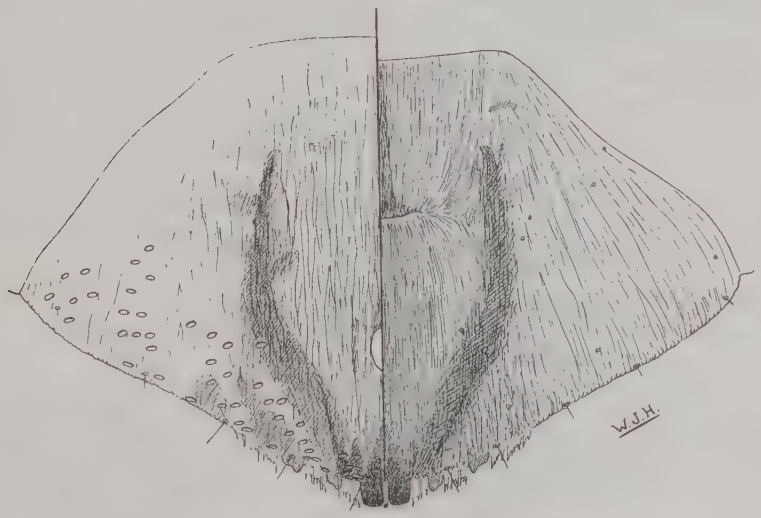

Fig. 3. *Aspidiotus* (*Hemiberlesea*) *rhodesiensis*, sp. n. : pygidium of adult ♀, × 120.

Apparently a common species in Southern Rhodesia. It has been collected in widely separated localities—Umtali, Mazoe and Banket. It is very closely allied to *Aspidiotus combreti*, but such is the artificiality of our present classification that, closely related although they are, the presence of circumgenital glands in the one and absence in the other demands that they should be allocated to two different subgenera.

6. **Aspidiotus** (**Selenaspidus**) **silvaticus,** Lind.

On palms, The Park, Bulawayo (Matabeleland), ex coll. Dept. of Agric. No. 1781 ; and on *Euphorbia ingens* (Euphorbiaceae), Greenwood Park, Salisbury, 2.iii.1928.

7. **Chrysomphalus aonidum,** L.

On palms, The Park, Bulawayo (Matabeleland), ex coll. Dept. of Agric. No. 1781. A few typical individuals of this cosmopolitan species were found intermingled with the scales of four other species on this palm. Up to the present I have not taken it on *Citrus*.

8. Chrysomphalus aurantii, Mask.

So far I have found this species only on *Citrus*. It occurs on the three Citrus estates belonging to the B.S.A. Company at Mazoe, Sinoia and Umtali, and is one of the principal pests on the two first named estates. It is kept well under control by fumigation. Climatic conditions at the Premier Estate, Umtali, which have a distinct coastal touch, do not appear to be so favourable to the development of this pest.

9. Chrysomphalus corticosus, Brain.

This species was taken on *Royena pallens* (Ebenaceae) at Macheke, 29.xi.1927. Rhodesian examples appear to be typical.

10. Chrysomphalus phenax, Ckll.

Collected on *Acacia karroo* (Leguminosae) at Umtali, 9.ix.1927.

11. Chrysomphalus ? pinnulifera, Mask.

On *Seaforthia* sp. and *Kentia* sp. (Palmae), Municipal Garden, Salisbury, 3.xi.1927. I do not always find it easy to separate *dictyospermi*, *pinnulifera* and its variety *diversicolor*, and the present material is a case in point. Referring to the above material Mr. Green says " The relatively short pygidium is more like that of *dictyospermi* ; but the entire pinnae and the angle of the median trullae are characteristic of *pinnulifera*. The colouration and pattern of the scale are intermediate between typical *pinnulifera* and the var. *diversicolor*."

12. Chrysomphalus pinnulifera var. **diversicolor,** Green.

On palms, The Park, Bulawayo (Matabeleland), ex coll. Dept. of Agric. No. 1781. Also on *Citrus aurantium* (Rutaceae), Mazoe and Umtali.

This material appears to be typical of var. *diversicolor*. It has been known to occur in small numbers in one or two groves at Mazoe and the Premier Estate, Umtali, for some years and has gone under the name of the Circular Purple Scale (*C. aonidum*, L.). The living specimens, indeed, are so alike that it was some time before I made preparations. As soon as these were made it was at once obvious that it was not *C. aonidum*, L.

13. Lepidosaphes brachystegiae, sp. n. (fig. 4).

Puparium of the adult female, small, of the shape typically found in this genus. Exuviae shiny golden or brown with a larger or smaller dark brown area, which never extends as far as the posterior extremity ; covered with a thin film of white secretionary matter. Nymphal exuviae nearly half as long as the entire puparium. Secretionary appendix white. The ventral scale is very thin but generally remains attached to the dorsal scale round the margin ; the median portion almost invariably remains attached to the host-plant. The living adult female is very dark, almost black. Length of fully developed female puparium 1·25–1·75 mm. ; breadth 0·4–0·6 mm.

Male puparium, small, of normal form, with pale brown exuviae.

Adult female with segmentation distinct, antennae reduced to two minute tubercles carrying two short curved bristles, one of which tends to be rather stouter than the other. Anterior parastigmatic orifices varying from 1 to 3, the usual number being 2. The two posterior free abdominal segments with a small tuberculiform process near the anterior border of the margin, the last two have, in addition, two to four (usually three) marginal gland spines, which are often forked at the apex. A few tubular spinnerets occur near the margin of the abdominal and thoracic segments, and in the two anterior abdominal segments small aciculate gland spines occur as well.

There is a well marked series of these gland spines running from a submarginal position towards the posterior spiracles. Pygidium broadly rounded. Median lobes set close together, triangulate, rounded at the apex and faintly crenulate. The 1st lateral lobes duplex, small, with the inner lobule the larger ; the 2nd lateral lobes duplex, very small and obscure, the inner lobule though small being much larger than the outer. Gland spines arranged as follows, one between the 1st and 2nd lateral lobes, one just beyond the 2nd lateral and one near the base of the pygidium. One or more of these is usually forked at the apex. Marginal gland orifices, one between the median and 1st lateral lobes (which is not always very conspicuous owing to the chitinization of the tissues in the vicinity), one between the 1st and 2nd lateral lobes, and three between the 2nd lateral and the base of the pygidium. Anal orifice nearer the base than the apex of the pygidium. Dorsal gland orifices smaller than the marginal glands, scattered, with no apparent regular arrangement. Circumgenital glands in 5 groups, median 3–5, anterior laterals 5–10, posterior laterals 3–8. Average of a number of examples 4 : 8 : 6. Dorsal surface of pygidium with well marked chitinized areas, as shown in the figure. Ventral dermis extremely delicate.

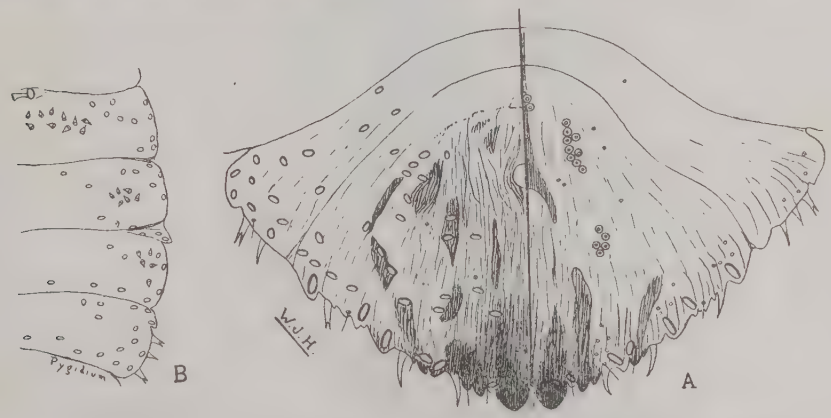

Fig. 4. *Lepidosaphes brachystegiae*, sp. n. : A, pygidium of adult ♀, × 117 ; B, margin of free abdominal segments and posterior thoracic segments, × 70.

On *Berlinia globiflora*, *Brachystegia flagristipulata* and *Brachystegia* spp. (Leguminosae) ; on the smaller branches. Mazoe, on various dates in August, September and October 1927.

I know of no *Lepidosaphes* quite like this, in which the forked gland spines are characteristic. It is not an easy species of which to get good preparations. In nearly all my specimens the body is full of eggs ; these will not clear in potash and in the final preparation often mask some of the important features. The ventral dermis is also excessively delicate and frequently thrown into folds, rendering it difficult to distinguish the number of circumgenital glands in each group. The marginal gland spines, also, do not always show up well.

14. Lepidosaphes hawaiensis, Mask.

On *Cassia tettensis* (Leguminosae) ; on the branches. Mazoe, 21.viii.1927.

Mr. Green has recently published a " Note on the synonymy of *Mytilaspis flava*, Targ. var. *hawaiensis*, Mask." (Ann. Mag. Nat. Hist. (10) i, p. 152, Jan. 1928). Rhodesian examples differ from the figures there given in the thinner and more

outwardly divergent nature of the conspicuous clavate paraphyses. In every case, also, the small lateral paraphyses are curved over and inwards in the form of a right angle and not straight as figured. In other respects the specimens appear to be typical.

15. Ischnaspis longirostris, Sign.

On palms, The Park, Bulawayo (Matabeleland), ex coll. Dept. of Agric. No. 1781.

This material was typical of this widely distributed species.

16. Diaspis carissae, sp. n. (fig. 5).

Puparium of the adult female oval. Exuviae semi-transparent and of a very delicate green or brown colouration; in some examples they appear colourless. Secretionary area pale green, whitish at the margin; semi-transparent. Ventral scale extremely thin, remaining adherent to the host-plant. Length of fully developed female puparium 1–1·3 mm. Breadth 0·8–1 mm.

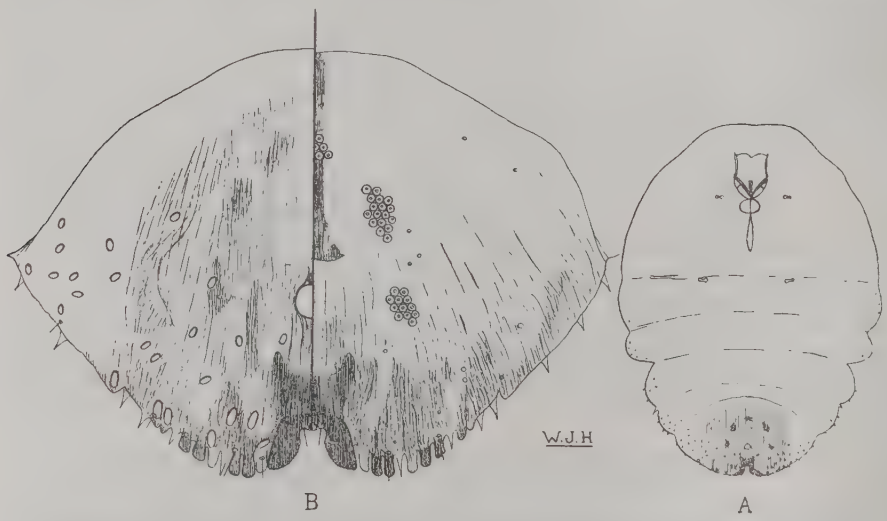

Fig. 5. *Diaspis carissae*, sp. n.: A, adult ♀, ×30; B, pygidium of adult ♀, × 142.

Male puparium of the normal shape, with very pale brown or colourless semi-transparent exuviae; conspicuously tricarinate. Length 0·8–1 mm.

Adult female approximately oval in outline. Antennae represented by two minute tubercles carrying 1 or 2 stout curved bristles, usually two. Anterior spiracles with 1–3, generally 2, parastigmatic glands. No apparent cephalothoracic tubercles. Free abdominal segments with a group of tubular spinnerets and very few gland spines marginally on the posterior two. Most preparations show one of these, which occurs between the 2nd and 3rd segments, to be larger and more conspicuous than the others. Pygidium broadly rounded, with a deep and conspicuous cleft, from the base of which arise the median lobes. The median lobes are separated at the base by a distance approximately equal to the width of one, inner edge rounded and finely serrate, outer edge straight. First and second lateral lobes duplex, the lobules elongate and truncated, the outer in each case being slightly smaller than the inner. Between the median lobes and 1st duplex lobes is a large projecting pore which is

Fig. 1. *Taeniorhynchus africanus:* pupa attached to duck-weed.

Fig. 2. *T. africanus:* pupa removed from duck-weed.

distinctly lobe-like. Between the 1st and 2nd duplex lobes is a gland spine of normal type and a second projecting lobe-carrying pore. There are two similar but less conspicuous projecting pores set close together and only separated from the 2nd duplex lobes by a gland spine. Another tooth-like projection and 4 or 5 gland spines occur between this and the base of the pygidium. There appears to be a large pore between the median lobes, but owing to the chitinization of the tissues only the capitate head can be discerned. Two large pores of a type similar to the marginal pores on either side, well within the margin, behind the first duplex lobes. Dorsal pores scattered and not very numerous, smaller in size than the marginal pores. Anal orifice situated nearer the apex of the pygidium. Circumgenital glands in 5 groups, median 7–12, anterior laterals 8–19, posterior laterals 7–15; average of 15 examples, 9 : 16 : 12. Ventral surface of pygidium with a few scattered, very minute tubular spinnerets.

On *Carissa edulis* var. *tomentosa* (Apocynaceae); on the leaves and smaller twigs. Umtali, 9.ix.1927.

This species comes near to *Diaspis regularis*, Newst., but differs from it in the absence of the conspicuous tooth-like prominence on each side of the pygidium. It possesses the same projecting pores simulating lobes described by Newstead as occurring in *regularis*.

17. Diaspis (Aulacaspis) cinnamomi, Newst.

On *Mangifera indica* (Anacardiaceae); on the leaves. Umtali, ex coll. Dept. of Agric. No. 1427.

This material was more typical of *cinnamomi*, Newst., and not, as I expected, of the variety *mangiferae*, Newst. According to Mr. Green there is no justification for separating the variety from typical *cinnamomi*, as the distinguishing characters break down in practice. In Rhodesian examples the median longitudinal black stripe on the exuviae is conspicuous, the median lobes are serrated, though hardly strongly serrated. An examination of 11 examples showed that the number of circumgenital glands was as follows: median 13–21, anterior laterals 24–38, posterior laterals 21–35; average 17 : 30 : 29. This shows the circumgenital glands to be more numerous than Newstead quotes in his original description, but Kuwana gives comparable figures in his description of the species in the "Diaspine Coccidae of Japan," 4th August 1926.

18. Howardia loranthi, sp. n. (fig. 6).

Puparium of adult female highly convex and roughly oval in outline; the shape varies considerably, some being more broadly oval and others more narrowly so. Exuviae overlapping the margin at the anterior extremity of the scale; they are shiny reddish brown in colour and covered by a thin white film of secretionary matter. The secretionary area is white with a tinge of brown. Some are whiter and others distinctly more brown. Larval exuviae half the length of the nymphal exuviae which are from half to one-third the length of the entire puparium. Ventral scale thin, generally breaking away on raising the scale but remaining adherent round the margin. Length 1–1·2 mm.; breadth 0·6–0·8 mm.

Adult female oval in outline. Antennae represented by minute tubercles each carrying a single short curved bristle. Anterior spiracles with from 1 to 4 parastigmatic glands, usual number 3 or 4. Free abdominal segments with a few minute tubular spinnerets marginally, the thoracic segments also carry a very few in a similar position. The last free abdominal segment carries 1 or 2 gland spines marginally. Pygidium broadly rounded. Median lobes set rather wide apart and outwardly deflected, rounded at the tip, with a very faintly serrate margin. The median lobes are chitinized and joined together at their bases by a band of chitin. Other lobes not apparent. On either side there are four groups of small tooth-like

projections ; the first group is close to the median lobe and is trifid, the next two are bifid, and the fourth consists of a single tooth-like projection. The squamae are delicate, spiniform, but rather broad at the base ; one between the 1st and 2nd tooth-like projections, one or two between the 2nd and 3rd, two between the 3rd and 4th, and three beyond the 4th. There is one rather large marginal pore to each tooth-like projection, that to the one nearest the median lobe being somewhat obscured by the chitinization of the tissues in the vicinity. Marginal pores slightly larger than dorsal pores. The dorsal tubular spinnerets are scattered without any apparent arrangement over the pygidium. Circumgenital glands wanting.

On *Loranthus guttatus* and *Loranthus* sp. (Loranthaceae) ; on the branches. Mazoe, 13.viii.1927 ; Sinoia, 21.ix.1927 ; Mazoe Dam, 20.xi.1927.

I am a little doutbful if this species is correctly placed in the genus *Howardia*. It has not a burrowing habit, nor has it paraphyses to the median lobes. On the other

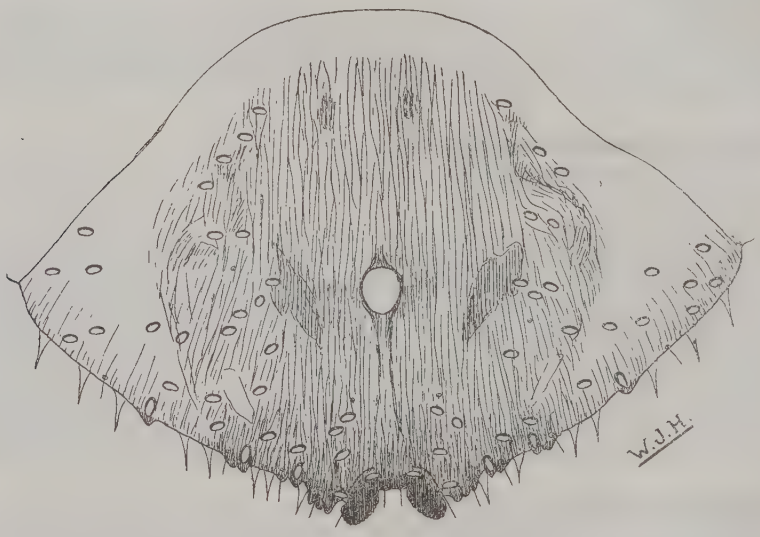

Fig. 6. *Howardia loranthi*, sp. n. : pygidium of adult ♀, × 187.

hand the female puparium is suggestive of *Howardia*, and the other pygidial characters conform to this genus. The male puparium was not found, although the plants were heavily infested.

19. Howardia rhusae, sp. n. (fig. 7).

Puparium of adult female variable in shape, usually subcircular but some specimens are oval or even pyriform. Exuviae overlapping the margin, larval exuviae shiny brown, nymphal exuviae similar but covered with a very thin semitransparent film. Secretionary area white, some specimens a dirty colour, almost brown, owing to incorporated matter. Ventral scale thin, usually remaining attached to the host-plant, except for a thin rim round the margin. Diameter 0·8–1·0 mm.

Adult female oval in outline, with antennae represented by minute tubercles carrying a single stout curved bristle. Anterior spiracles with 2–4 parastigmatic glands. Free abdominal segments with a few small tubular spinnerets marginally.

Pygidium triangular, rounded at the tip. Median lobes widely set apart and divergent, somewhat pointed and minutely serrated on their inner margins. A broad chitinous band joins the base of the two lobes. Other lobes inconspicuous or very poorly developed. There are 7 short gland spines at intervals on either side. Marginal pores 6 or 7 on each side, one also occurs between the two median lobes but owing to the chitinization of the tissues is not very obvious. On either side of this, at the base of the lobes, is what also appears to be a pore, but I cannot make this out, nor can I detect the capitate head. The marginal pores are of the same size as the

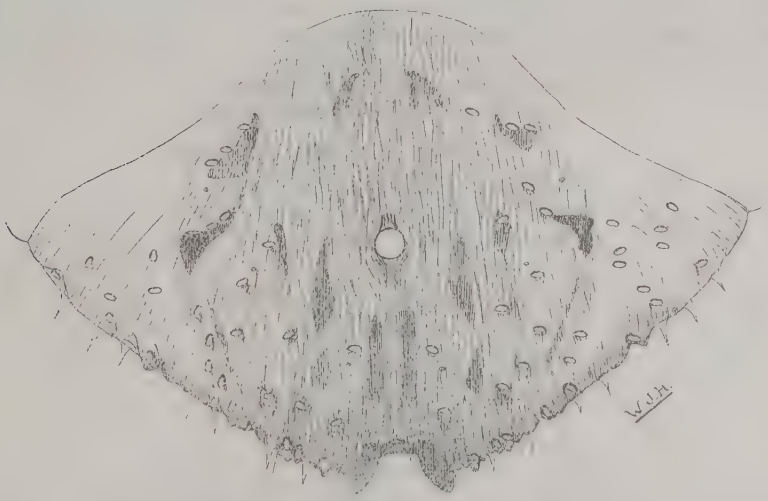

Fig. 7. *Howardia rhusae*, sp. n.: pygidium of adult ♀, × 123.

dorsal pores and not very conspicuous. Dorsal pores scattered over the pygidium without any apparent definite arrangement. Anal orifice circular, situated near the centre of the pygidium. The pygidium shows more or less constant chitinous areas; one very pronounced one is always conspicuous on each side wide out near the base. Circumgenital glands absent.

On *Rhus villosa* and *Rhus* spp. (Anacardiaceae); on the small branches. Mazoe, 13.viii.1927; Embeza, 10.ix.1927 and 11.iii.1928.

This species, I believe, is correctly assigned to the genus *Howardia*. I can trace no species exactly comparable to it. *Diaspis rhusae* of Brain is obviously quite distinct from it.

20. Chionaspis sinoiae, sp. n. (fig. 8).

Puparium of adult female of irregular form, usually narrowed in front and broadened behind. Some examples are much wider posteriorly than others, whilst others are curved and irregular owing to obstacles encountered in their development. Usually found to a greater or lesser degree under the surface tissue of the bark. Exuviae overlapping the margin, the larval exuviae being pale brown to brownish green, the nymphal exuviae deeper brown, almost orange. Exuviae covered by a thin white secretionary film. Secretionary area white. The exuviae occupy about a third of the total length of the puparium. Ventral scale thin, remaining attached to the host-plant except for a narrow strip round the margin. Length 2–3 mm.

Male puparium pure white, with pale brown exuviae, broadening slightly posteriorly ; non-carinated. (These remarks on the male puparium are based on an examination of damaged and imperfect specimens only.)

Adult female pyriform, narrowed in front, widest across the first free adbominal segment. Antennae represented by minute tubercles carrying one or two rather long stout curved bristles. Anterior spiracles with 4–6 parastigmatic glands. Segmentation distinct. Segments with a few large tubular spinnerets lying along the junction of the segment with that next behind. These are more numerous in the lateral extensions of the segments marginally, which carry, in addition, a few acicular gland spines. The latter occur also on the thoracic segments, together with scattered tubular spinnerets of a somewhat smaller size than those found on the abdominal segments. Pygidium broadly rounded, with a pair of conspicuous median lobes which are slightly divergent and serrated on all but their inner edges ; old specimens

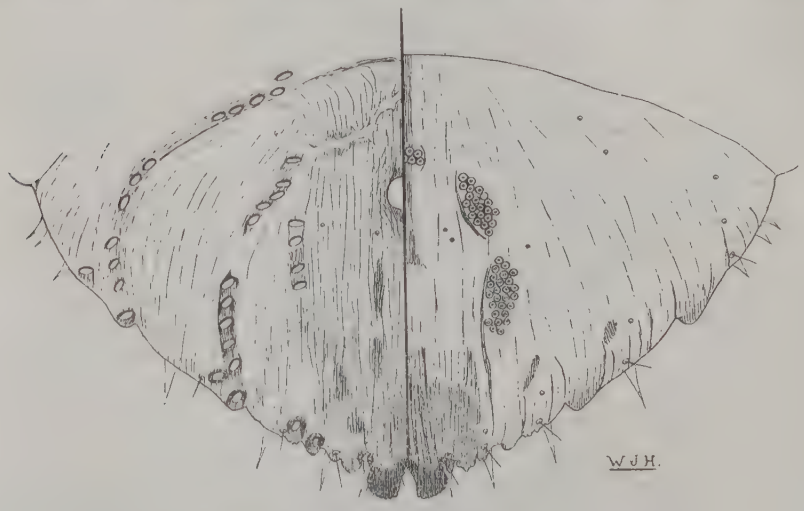

Fig. 8. *Chionaspis sinoiae*, sp. n. : pygidium of adult ♀, × 102.

show the serrations in more marked fashion. The lobes are rounded and set apart by about half the width of one. The median notch is acute. The first lateral lobes are but poorly represented, duplex, with the inner lobule the larger. A small sharply pointed glandular prominence occurs between the median and 1st lateral lobes ; this is conspicuous owing to the chitinization of the tissues surrounding the pore. Three more glandular projections occur between the lateral lobes and the base of the pygidium. There are 4 gland spines at intervals on either side of the median lobes, and at the base of the pygidium a group of usually 3 gland spines of a smaller type. Dorsal pores large and conspicuous in three well-marked but interrupted series. The innermost series is generally represented by 4 or 5 pores only. Anal orifice situated nearer the base of the pygidium. Circumgenital glands in 5 groups, the average of a number of examples being median 10, anterior laterals 21, posterior laterals 26. In my examples there is no very great variation in the number of these glands.

On unknown plant. Sinoia, 22.ix.1927.

The specimens were found on the main trunk of a small tree in the veldt. Unfortunately the tree was exhibiting no foliage and in order to get the specimens the whole tree had to be cut down. It has, therefore, been impossible to get it identified.

It is a little difficult to know whether this species should be placed in the genus *Chionaspis* or *Lepidosaphes*. Such male puparia as I have been able to find have all been damaged, but they appear to conform to the type found in the former genus, to which I have assigned it.

21. Chionaspis (Pinnaspis) chionaspiformis, Newst.

On unknown shrub. Banket, 22.ix.1927.

This material was collected in the veldt and owing to the fact that the shrub had no foliage on it of any kind it was impossible to get it identified. *P. cassiae, chionaspiformis, indigoferae,* and *communis,* constitute a very compact and closely related group.

Material collected on *Lannea discolor* (Anacardiaceae) at Salisbury, 23.xi.1927, and at Macheke, 29.xi.1927, I have also assigned to this species.

22. Chionaspis (Pinnaspis) combreti, sp. n. (fig. 9).

Puparium of adult female elongate pyriform, narrowed in front, broadening gradually posteriorly ; frequently distorted in shape. Larval exuviae brown to dark bronze, nymphal exuviae brown or reddish brown, covered by a thin film of white

Fig. 9. *Chionaspis (Pinnaspis) combreti,* sp. n. : pygidium of adult ♀, × 115.

secretionary matter, which obscures the colour. The exuviae occupy about a third of the entire puparium. Secretionary appendix white, often with portions of the brown tissues of the bark incorporated. The puparia are generally speaking a pale brown and do not show up against the brown ground-work of the bark. They are frequently partly covered by the tissues of the bark. Ventral scale very thin, only remaining adherent round the margin when lifted from the host-plant. Length 1·8–2 mm. Breadth 0·7–0·8 mm.

Male puparium white, with straw-coloured exuviae ; non-carinated.

Adult female narrowed in front, broadest about the 2nd free abdominal segment. Antennae represented by minute tubercles carrying one or two stout curved bristles ; where two are present they are of unequal sizes. Anterior spiracles with a compact

rounded group of 4–8 parastigmatic glands. It is not always easy to detect the number of the orifices, owing to the rounded nature of the compact mass formed by them. Free abdominal segments with numerous short tubular spinnerets marginally, which extend inwards, thinning off into a more or less single row, which very nearly reaches the median line, also with a small group of aciculate gland spines near the margin. The spinnerets and gland spines are also found on the thoracic segments, the latter tending to be more numerous in the vicinity of the spiracles than on the abdominal segments. Pygidium broadly rounded with median lobes prominent and in close apposition, serrated except on their outer edges. There are two pairs of small duplex tooth-like lobes on either side ; they do not appear to be of a glandular nature and may represent the lateral lobes ; they are not infrequently somewhat obscure. A small glandular spine occurs on each side of the median lobes and close to them. A rather larger spine of a similar nature occurs just beyond the 1st lateral duplex lobe. Just beyond the 2nd duplex lobe one large and one or two markedly smaller gland spines occur with their bases close together. A similar group occurs further out, and three or four usually scattered spines are found near the base. Dorsal pores with relatively small orifices, scattered, but two interrupted series can usually be detected. A conspicuous right-angled chitinized fissure occurs on either side between the anal orifice and the base of the pygidium. Anal orifice nearer the base. Circumgenital glands in 5 groups : median 2–9, anterior laterals 13–22, posterior laterals 12–26. Average of 15 examples 6 : 17 : 21. The median group is sometimes split into two smaller groups.

On *Combretum* sp. (Combretaceae) ; on the larger branches. Mazoe, 17.xi.1927.

This species can be readily separated from the other Rhodesian species of *Pinnaspis* by the nature of the median lobes.

23. Chionaspis (Pinnaspis) communis, sp. n. (fig. 10).

Puparium of adult female white, elongated, moderately dilated behind ; crowded examples usually curved. Larval exuviae pale brown, nymphal exuviae darker brown or orange-brown, covered by a thin white film. The exuviae occupy about five-twelfths of the length of the entire puparium. Secretionary appendix white, with faint transverse striations. Ventral scale thin, usually persisting over the anterior half or rather more, with a median longitudinal ragged fracture. In some specimens the entire ventral scale breaks away and remains attached to the host-plant. The living adult female is yellow, yellow green or orange, with brown pygidium. Length 1·75–2·25 mm. ; breadth 0·75–1 mm.

Male puparium white, with golden exuviae ; non-carinated.

Adult female of normal form, narrowed in front and broadest across the first free abdominal segment. Segmentation marked, the segments being produced laterally. Antennal tubercles minute, carrying one or two curved bristles and a short pyramidal prominence. Anterior spiracles with a crowded group of parastigmatic glands ; the number is 7–14, but they are difficult to count owing to their crowded nature and the fact that they rarely appear to lie in one plane. Abdominal segments with scattered large tubular spinnerets near the margin and a small group of aciculate gland spines. Similar spinnerets and gland spines occur on the meso- and metathorax, but in this case they extend more inwards from the margin. Pygidium with prominent median lobes. These are in close apposition, broadly rounded, with a deep notch on the outer edge. Some examples show a small notch on the inner surface of one of the lobes. In old examples the lobes are often worn practically round. Lateral lobes wanting. On either side there are three duplex tooth-shaped prominences ; the glands supplying these are heavily chitinized and render them very conspicuous. Between the median lobe and the first duplex tooth-gland are two gland spines, two or three more occur between the 1st and 2nd pairs, three or four (one of which is usually considerably

stouter than the others) between the 2nd and 3rd, three or four beyond the 3rd pair, and a group of 5 or 6 towards the base of the pygidium. These gland spines are longer than and of a different type from those found on the abdominal segments. Those on the last free abdominal segment are of an intermediate form. Circumgenital glands in 5 groups : median 0–9, anterior laterals 10–31, posterior laterals 17–38; average of 15 examples, 6 : 21 : 30. Anal orifice relatively small, slightly nearer the base than the apex of the pygidium. Dorsal pores large and numerous, in two conspicuous interrupted series, the pores being crowded near the margin.

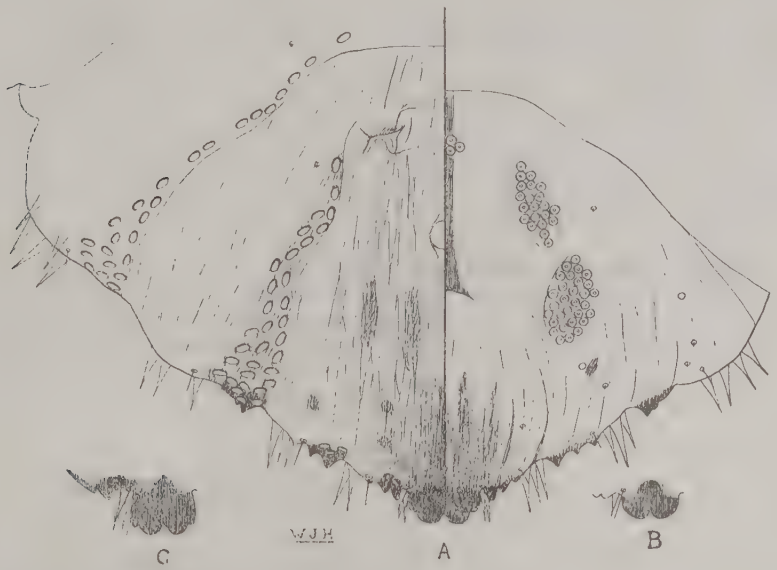

Fig. 10. *Chionaspis* (*Pinnaspis*) *communis*, sp. n. : A, pygidium of adult ♀ ; B, var. *berliniae*, n., median lobes ; C, var. *monoies*, n., median lobes. × 117.

On *Ficus capensis*, *Ficus* spp. (Moraceae), and *Zizyphus jujuba* (Rhamnaceae) ; on the branches, both large and small.

Collected at Mazoe, Headlands, Macheke and Sinoia. It is extremely common on the native species of *Ficus*. It comes near to *cassiae*, *chionaspiformis* and *indigoferae* but has more dorsal pores than are found in any of these. The material on *Zizyphus* appeared to be typical.

24. Chionaspis (Pinnaspis) communis var. **berliniae,** var. n. (fig. 10, B).

Differs from typical *communis* in the nature of the median lobes, which are smaller and show no marked notch on the outer edge.

The circumgenital glands appear to be very variable, being generally less but sometimes more than occur in *communis*. There is a tendency for the dorsal pores on the pygidium to be rather fewer.

On *Berlinia globiflora* (Leguminosae) ; on the small branches. Theydon, 28.xi.1927.

This is a difficult species to place. There are many small differences from *communis*, but these are difficult to describe, the only marked difference being in the shape of the median lobes, and this is so consistent that it must be considered a variety of that species.

25. Chionaspis (Pinnaspis) communis var. **monotes,** var. n. (fig. 10, C).

Differs from typical *communis* in the larger size of the gland spines on the pygidium, and in the somewhat greater number of circumgenital glands. The average of a number of examples was : median 8, anterior laterals 28, posterior laterals 36. Most specimens show rather fewer dorsal pores and more prominent median lobes. The median lobes of the nymphal exuviae are also more prominent than in the case of typical *communis*.

On *Monotes glaber* (Dipterocarpaceae) ; on the larger and smaller branches. Sinoia, 21.ix.1927 ; Mazoe Dam, 20.xi.1927.

Whilst this form is admittedly very close to *communis*, a long series of examples shows constant small but distinct differences, which, in my opinion, are sufficient to establish this material as a variety.

26. Chionaspis (Pinnaspis) indigoferae, sp. n. (fig. 11).

Puparium of the adult female small, of variable shape, narrowed in front, broadened behind ; some examples are short and much broadened, others are larger and not so broad. Exuviae overlapping the margin ; larval exuviae dark greenish brown, paler

Fig. 11. *Chionaspis* (*Pinnaspis*) *indigoferae*, sp. n. : pygidium of adult ♀, × 212.

round the margin ; nymphal exuviae yellow to golden, covered by a thin film of white secretionary matter. The exuviae occupy from a quarter to a third the length of the puparium. Secretionary appendix white. Ventral scale very thin, remaining adherent to the host-plant except for a small rim round the margin. Length 1·25–1·5 mm. ; breadth 0·5–0·8 mm.

Male puparium with pale brown exuviae, broadening very slightly posteriorly and faintly tricarinate. Length 1 mm.

Adult female small, oval in outline. Antennae reduced to minute tubercles carrying a single curved bristle. Anterior spiracles with 0–5 parastigmatic glands, the usual number being 3. Abdominal segmentation distinct; in the marginal area of each segment are a number of large short tubular spinnerets, a few spinnerets of a smaller size and 2 or 3 aciculate gland spines. In the thoracic region the large spinnerets are much fewer in number, but spinnerets of the smaller size are, if anything, more numerous. Gland spines occur but are not numerous, 7 or 8 are found between the margin and the anterior spiracles on either side. Pygidium broadly rounded. Median lobes small, faintly bicuspid, with their bases in apposition. Other lobes not apparent. Two very small projections set close together on either side of the median lobes appear to be of a glandular nature. A very small glandular prominence occurs beyond the duplex projection. Gland spines small and inconspicuous, one between the median lobe and lateral duplex projection, a second between this and the glandular prominence, two more close together beyond this, and one far out. At the base of the pygidium there are two or three gland spines of the same length but stouter. Dorsal pores scattered, in four obscure interrupted series. Anal orifice set midway between the apex and base of the pygidium. Circumgenital glands in 5 groups; median 0–11, anterior laterals 6–14, posterior laterals 0–14. Average of 21 examples, 7 : 11 : 10. In one case the median group was unrepresented, and in two cases one of the posterior lateral groups was missing. Ventral dermis delicate, with a few scattered very minute tubular spinnerets.

On *Indigofera* sp. (Leguminosae); wherever the stem forked. Sinoia, 21.xi.1927.

This species comes very close to *P. communis*, from which it may be distinguished by its smaller size, fewer circumgenital glands and dorsal pores, and inconspicuous gland spines.

27. Chionaspis (Phenacaspis) dilatata, Green.

On palms, The Park, Bulawayo (Matabeleland); ex coll. Dept. of Agric. No.1781.

28. Chionaspis (Dinaspis) mashonae, sp. n. (fig. 12).

Puparium of the adult female large and convex, narrowed in front and much broadened behind. Younger specimens, before the secretionary appendix has been fully developed, appear more broadly dilated than older specimens. Exuviae overlapping the margin; larval exuviae straw-coloured to reddish brown, with a median longitudinal carina; nymphal exuviae brown or orange, overlaid with a thin film of white secretionary matter. The exuviae occupy about a third of the length of the fully matured puparium. Secretionary appendix white. Where two or more specimens lie close together the secretionary appendices are fused. Ventral scale remaining attached to the host-plant except for a thin strip round the margin. Length 3–3·75 mm.; breadth 1·5–1·75 mm.

Adult female large, oblong, broadest across the first free abdominal segment. Abdominal segmentation distinct, with prominent lateral extensions to the segments. Antennal tubercles with 1 or 2 conspicuous stout blunted processes and usually 2 curved bristles. Anterior spiracles with a group of about 12 parastigmatic glands; a smaller group of 5 or 6 is found associated with the posterior pair. In old specimens the thoracic region shows signs of chitinization. The last free abdominal segment carries two groups of large pores, the marginal group being very much the larger and conspicuous by virtue of the large number of pores and their crowded nature; this group runs down into the posterior region of the lateral marginal extension. The other group is very much smaller and lies more or less along the junction of this segment and the pygidium, midway between the median line and the margin. On the anterior

portion of the lateral marginal extension are about 7 small gland spines of the same type as those found at the base of the pygidium but rather smaller. The penultimate free abdominal segment carries two similar but much smaller groups of conspicuous pores and 4 or 5 gland spines of a more aciculate type than those on the last segment. The anterior abdominal and posterior thoracic segments with a few scattered large pores near the lateral margin and a few aciculate glandular papillae. Pygidium broadly rounded. Median lobes divergent, squat and rounded, with a conspicuous tooth on the inner edge. Median notch acute and recessed, with a small but conspicuous highly chitinized circumscribed area, which spreads out to embrace the base of the lobes. A small seta on either side of the median notch is present. Lateral lobes duplex and inconspicuous. First pair with inner lobule the larger and rounded, the outer lobule rounded but falling away on its outer margin with indications of a notch.

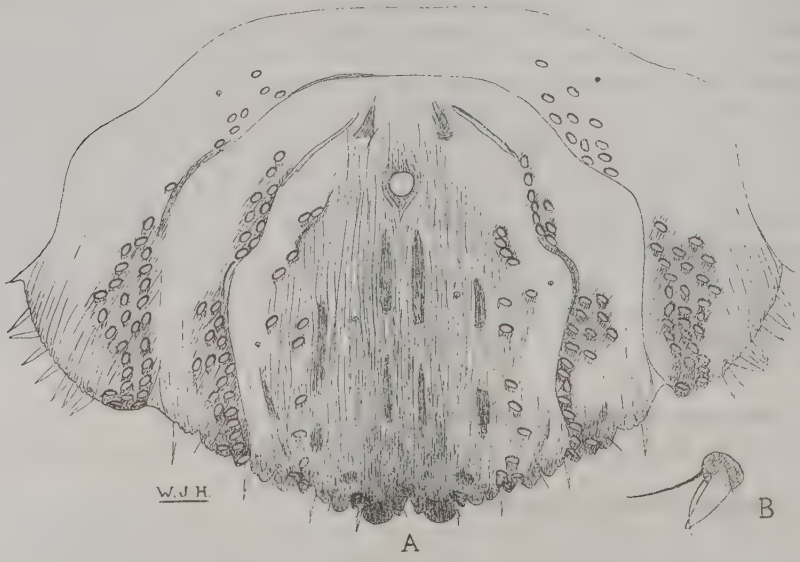

Fig. 12. *Chionaspis* (*Dinaspis*) *mashonae*, sp. n., adult ♀: A, pygidium, × 111; B, antenna.

Second pair similar in shape, but the inner lobule has a small notch on either side, and the outer lobule has a number of small notches on its outer margin. Between the median lobe and 1st lateral lobe is a gland spine and a tooth-shaped glandular protuberance, conspicuous on account of the chitinization of the tissues immediately surrounding the pore. Similar gland spines and glandular protuberances between the 1st and 2nd lateral lobes and immediately beyond the 2nd lateral lobe. Beyond this the margin is minutely but sharply and irregularly serrated, with a further gland spine. At the base of the pygidium there is a group of 7 or 8 gland spines. Anal orifice situated towards the base of the pygidium. Dorsal pores large and conspicuous, in three interrupted series, the innermost series being composed of a few pores, the arrangement of which is sometimes a little obscure. In the other two series the pores occur in two crowded elongate groups on either side, the marginal group in each case being the more conspicuous owing to the larger number of pores and their crowded nature. Circumgenital glands wanting.

On *Uapaca nitida* (Euphorbiaceae); on the smaller branches. Banket, 22.ix.1927.

This is unlike any other species of *Dinaspis* known to me.

29. Chionapsis (Dinaspis) proteae, sp. n. (fig. 13).

Puparium of adult female pyriform, moderately dilated behind. Larval exuviae brown, somewhat paler posteriorly ; nymphal exuviae golden. Exuviae overlaid with a film of white secretionary matter which obscures the colour. Secretionary appendix white, with obscure transverse striations. The exuviae occupy about three-eighths of the total length of the puparium. Ventral scale thin, usually remaining attached to the host-plant except round the margin. Length 1·7–2 mm. ; breadth 0·8–1 mm.

Male puparium not seen.

Adult female of normal shape. The rudimentary antennae are very variable, consisting of a small tubercle carrying from 1 to 5 blunt, stout and slightly curved spines and usually 2 curved hairs. The spines may be all of one size or of different sizes ; in cases where only one or two are present they may be distinctly larger, with sometimes a slight incision near the apex. Parastigmatic glands 1–8 in a small group associated with the anterior spiracles and 0–2 with the posterior spiracles. In

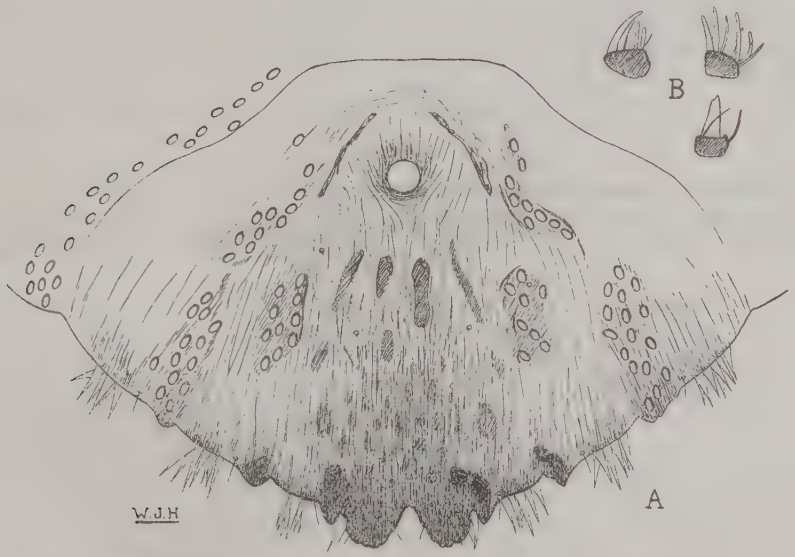

Fig. 13. *Chionaspis* (*Dinaspis*) *proteae*, sp. n., adult ♀: A, pygidium, × 140 ; B, variations in form of antenna.

old specimens all but the free abdominal segments become heavily chitinized : this chitinization is less dense in the frontal region. Abdominal segments with scattered tubular spinnerets marginally and a small group of aciculate gland spines. The spinnerets are of a somewhat smaller type than those found on the pygidium. They are more numerous on the posterior abdominal segments, where they are arranged approximately in a single transverse row lying along the junction with the segment next behind and in a small group marginally. The gland spines are more numerous on the first two abdominal segments. Thoracic segments with a few tubular spinnerets of a slightly smaller size than those on the abdominal segments. Pygidium with two large median lobes separated by a rather deep cleft. The lobes are broadly rounded with usually 3 or 4 conspicuous serrations on their apices. On either side of the median lobes and set close to them is a tooth-shaped prominence ; 2 similar but less conspicuous prominences occur at intervals between this and the base of the pygidium.

A gland spine arises from between the median lobe and 1st tooth-shaped prominence, a group of about 7 between the 1st and 2nd (usually one of these is rather larger and more conspicuous than the rest), 7 between the 2nd and 3rd, and again a group of about 7 between the 3rd and the base of the pygidium. One or more of these is generally knocked off, but the number can be ascertained from the small capitate heads discernible just within the margin. At the base of the median lobes and towards the outer edge a stout hair and 2 or 3 slender gland spines arise. It is difficult to make out more than the bases of these owing to the chitinization of the median lobes. Each tooth-like prominence associated with a marginal gland. Dorsal pores relatively large and arranged in three well-marked interrupted series. Ventral dermis of the pygidium with a few scattered small tubular spinnerets. Anal orifice situated near the base of the pygidium. Circumgenital glands wanting.

On *Faurea saligna*, *Protea abyssinica*, *Protea* spp. (Proteaceae); on the small branches. Rusape, 6.ix.1927; Cleveland Dam, 4.xii.1927; Darwendale, 14.xii.1927 and 26.iii.1928.

I cannot trace any *Dinaspis* similar to this; the groups of gland spines on the pygidium are conspicuous and separate it at once from any other species to me. Mr. Green informs me that it comes nearest to *giffordi*, Leon., of which I have not the description.

The type selected for this species is a young adult female in which the tissues have not yet become chitinized.

30. Chionaspis (Dinaspis) reticulata, sp. n. (fig. 14).

Puparium of adult female mytilaspiform, often curled, and very convex. Exuviae overlapping the margin: larval exuviae golden or shiny brown; nymphal exuviae

Fig. 14. *Chionaspis* (*Dinaspis*) *reticulata*, sp. n., adult ♀: A, pygidium, × 150; B, chitinous reticulation of the dermis.

similar but covered with a thin coating of white secretionary matter. Secretionary appendix white, almost silvery white, with obscure transverse striations. Exuviae about three-eighths the length of the entire puparium. Ventral scale thin, usually breaking away on lifting up the scale and only remaining adherent along the anterior margin. Length 1–1·25 mm.; breadth 0·5 mm.

Male puparium white, small, with subparallel sides ; either non-carinated or with the median longitudinal carina poorly developed. Exuviae shiny brown to golden.

Adult female elongate pyriform, narrowed anteriorly, with the frontal margin flattened. Older specimens with the thoracic region chitinized, this chitinization is laid down in polygonal areas with clear or less chitinized tissues between. In old examples the entire body is more or less chitinized. Antennal tubercles larger than usual, carrying one curved bristle and 3 or 4 very short blunt spines. Anterior spiracles with 1–4 parastigmatic glands—usually 3. Free abdominal segments with a few large tubular glands and gland spines in the marginal region. Pygidium broadly rounded ; median lobes widely set apart and deflected outwards, rounded, with a faintly serrated margin. Median notch deep and wide, with a chitinous bar running round it and joining up with the bases of the lobes on either side. A small seta arises from the middle of each side of the notch. First lateral lobes duplex, the inner lobule being the larger; both lobules are tusk-like. Other lobes wanting. I am a little doubtful if these are really true lobes, as the inner lobule appears as though it may be of a glandular nature. Gland spines occur 4 on either side, one between the median and 1st lateral lobes, one just beyond the lateral lobes, and two towards the base widely set apart. Anal orifice rather nearer the base than the apex of the pygidium. Dorsal pores large and conspicuous, arranged in three series. Marginal pores, one between the median and 1st lateral lobes, two between the 2nd and 3rd gland spines, two between the 3rd and 4th gland spines. Circumgenital glands absent.

On *Capparis corymbifera* (Capparidaceae) ; on the small branches. Mazoe, September and October 1927.

A well marked species. Dr. Brain has recorded three species of *Chionaspis* from *Capparis albitrunca* in South Africa, but it is quite distinct from any of these.

31. Chionaspis (Dinaspis) uapacae, sp. n. (fig. 15).

Puparium of the adult female opaque white, of elongate form, broadening slightly posteriorly and highly convex. Larval exuviae brown or golden, with a very thin translucent covering, which is much denser over a small area at its posterior extremity giving it the appearance of being white in this region. Larval exuviae with a well-marked median longitudinal carina ; nymphal exuviae brown or golden, covered with a thin semitransparent white film, which is again denser and more opaque over the posterior extremity. Secretionary appendix white, with obscure transverse striations. Ventral scale thin, remaining intact anteriorly and round the margin. The exuviae occupy about three-eighths of the length of the puparium. Length 1·7–2 mm. ; breadth 0·4–0·6 mm.

Male puparium of usual form, white, tricarinated, with shiny brown or golden exuviae.

Adult female elongate pyriform, narrowed in front. Antennal tubercles unusually large, set close together, each carrying a single outwardly curved stout bristle. Anterior spiracles with 4 or 5 parastigmatic glands, posterior pair with from 2 to 5. Free abdominal segments with scattered tubular spinnerets in the marginal region, which tail off into a single transverse row towards the median line ; these occur also in smaller numbers in a similar position on the posterior thoracic segments, but in the vicinity of the anterior spiracles they are replaced by spinnerets of a much smaller size. Free abdominal segments with groups of gland spines midway between the margin and the median line. Pygidium broadly rounded. Median lobes of medium size, set wide apart, outwardly deflected and flattened. The notch between the median lobes is deep, and a conspicuous chitinous band joins the base of the two lobes. Other lobes wanting or obscure. Four gland spines on either side and five marginal pores set in chitinous thickenings. Dorsal pores arranged in relatively well-defined

interrupted series, the inner series being often very incomplete and irregular. Anal orifice small, set near the base of the pygidium. Circumgenital glands absent. Old specimens become chitinized in all but the pygidium and posterior abdominal segments.

On *Uapaca kirkiana* (Euphorbiaceae) ; on the stems and leaves ; in many cases seen the entire plant or tree was white with this scale.

Fig. 15. *Chionaspis* (*Dinaspis*) *uapacae*, sp. n., adult ♀: A, pygidium, × 166 ; B, antenna ; C, aciculate gland spine from free abdominal segment.

This is a very common species on this host-plant and is apparently widely distributed in Southern Rhodesia. Its characters are such that it should be readily separated from the other species of this genus.

The specimen selected as type is a young adult female before chitinization has set in.

Mazoe, Southern Rhodesia, 1.vii.1928.

A NOTE ON THE LARVA AND PUPA OF *TAENIORHYNCHUS* (*MANSONIOIDES*) *AFRICANUS* (DIPT., CULICIDAE).

By S. L. M. Summers Connal, M.B.E., M.A., B.Sc.,
The Medical Research Institute, Lagos.

(Plate XIII.)

In the grounds of the Medical Research Institute at Yaba, near Lagos, some 200 yards north-east of the laboratories there is a swamp, roughly circular, its diameter being about 20 yards. Until the present year, since first coming under observation in 1908, it has been definitely a pond, formerly used for watering cattle ; small in the dry season, it sometimes assumed the dimensions of a lake in the rainy season. While it was a pond it harboured at least three different kinds of fish, and except for a few Anopheline larvae on rare occasions it was not a suitable breeding-place for mosquitos owing to the activities of the fish.

During the dry season of two years ago, for some reason, the fish disappeared. In the following wet season the number of Anopheline larvae was so great that oiling was resorted to on several occasions. This year (1928) duckweed (*Lemna aequinoctialis*, Welw.)* has appeared for the first time. On examining the water in March it was noticed that there were numerous small larvae, which on closer inspection were thought to be those of *Taeniorhynchus* (*Mansonioides*) *africanus*. The larvae were observed to be distinctly sluggish in their movements and were not attached to the roots of the duckweed. By blowing on the surface and obtaining a clear space, the larvae could be seen coming slowly to the top. It was perfectly easy to dip in a spoon and capture them. If they were missed they did not dart away to the bottom as most other mosquito larvae do, they merely slowly came up again. In the complete absence of *Pistia* in the water it was thought advisable to collect as many as possible and place them in a large breeding tank for observation.

As the larvae grew older they attached themselves by the siphon to the lower surface of the leaves of the duckweed. Further observations are being made on this habit.

Immediately after pupating, the pupa attached itself also to the lower surface of a leaf. This process was definitely observed. The two trumpets were approximated and pierced the leaf so that the pupa lay almost entirely concealed by the piece of duckweed, the trumpets just protruding through the upper surface of the leaf.

On no occasion were either larvae or pupae observed attached to the roots of the duckweed.

The first six pupae to be examined were thought to be dead. They were placed in a watch-glass under the dissecting binoculars, turned over with pins, shaken and prodded, but made no movement. Microphotographs of them in various positions were taken and they were then set aside preparatory to being preserved. Next morning they had all hatched.

* [Kindly identified by Mr. J. E. Dandy, of the British Museum.—Ed.]

A STUDY OF *COLASPIS HYPOCHLORA*, LEFÈVRE.

By GEORGE SALT, D.Sc., F.E.S.

Introduction and Acknowledgments.

In the banana-producing area of north-eastern Colombia and in certain parts of Central America, the skins of the banana fruits are sometimes attacked by insects, which gnaw the epidermal tissues and cause unsightly, blackened scars. In some districts so much fruit is thus affected that the matter has become of considerable economic importance; measures intended to reduce the injury have been initiated and studies of the causal organisms commenced.

In the Santa Marta region of Colombia, whence by far the greatest amount of scarred fruit comes, two insects are concerned ; a beetle, *Colaspis hypochlora*, Lefèvre, and a bee, *Trigona amalthea*, Olivier ; but only the former, the subject of this report, is of primary importance.

The injury caused by *Colaspis hypochlora* consists in a removal of the outer layers (epidermis and some of the underlying parenchyma) of the fruit skin. The latter is not completely perforated and the edible part of the fruit remains quite unharmed, but the injured surfaces turn black and form such ugly scars that the fruit is rendered unfit for sale in the fastidious northern markets. The individual scars are irregular in shape and size but always have rounded ends, are usually elongate oval, and seldom exceed a length of 15 mm. and a width of 5 mm. On a badly infested finger they are so numerous and approximate each other so closely that large parts of the surface are entirely blackened. The scars may occur on any part of the banana, but owing to the beetle's preference for shady situations they are usually concentrated on the lower surface at the proximal end. Bee injury may be readily distinguished from that of the beetle ; the scars have a sharper outline, are frequently triangular, and, owing to the inability of the bee's mandibles to grasp the flat surface of the banana, are confined to the longitudinal ridges on " thin " fruit.

The early history of the infestation in Colombia is very obscure. Old inhabitants assert that the cultivations have always suffered more or less from scarring, but whether of the beetle or of the bee is not certain. The black bees, eating the exposed ridges of the fingers, are much more conspicuous than the dull brown beetles, attacking mainly the underside of the hand ; and it is scarcely surprising that injured bunches were spoken of as " bee stung " fruit. At any rate, until 1922, when the infestation became so greatly augmented as to attract definite and official attention, all the injury was attributed to the bee. On account of this confusion of the records it is impossible definitely to trace the infestation back any further, although it is claimed in some quarters that beetle injury was distinguished and the beetle itself recognised as early as 1918.

The outbreak of 1922, at any rate, was the first that was serious enough to cause investigation. It seems to have been general throughout Rio Frio, Orihueca, and Sevilla districts, the northern part of the banana zone, but in Tucurinca and Aracataca districts, to the south, according to the records of the United Fruit Company, there was practically no trouble. The following year the beetle spread and its injury increased. A report upon it was rendered to the Company, and experimental spraying and dusting were carried on. In the very wet year 1924, further increase was reported, and some of the worst infested areas were regularly sprayed. The peak of the outbreak was reached in either 1924 or 1925 : definite figures for the former year are not available. In 1926 a vigorous spraying campaign was organized in six of the most seriously infested farms and was carried on until the end of the year, but the results were very unsatisfactory and the treatment was not repeated in 1927. The survey made at the

end of the year 1926 showed a decrease in injury in all parts of the region, and the year 1927 has witnessed another considerable reduction. The present report includes a study of that reduction, and gives reason to expect a continuance of the decline and a gradual lowering of the damage to a negligible minimum.

To Dr. J. R. Johnston and Mr. A. A. Pollan, of the United Fruit Company, I am indebted for their interest in and kind furtherance of my work. The entire personnel of the Colombia Division and particularly of the Agricultural Department of the same Company ably and willingly assisted. To those who made previous investigations of the pest, Messrs. Gowdey, Walker, and Keil, I am grateful for the guidance furnished by their reports. Finally, I heartily thank my companions and friends, Mr. S. A. Svenningsen and Mr. J. Keil, whose faithful assistance and helpful advice contributed materially to my study.

Taxonomic Notes.

As at present defined, the genus *Colaspis* includes a large assemblage of forms. Clavareau (1914) lists 199 species, and undoubtedly many more remain to be described as the neotropical beetle fauna becomes better known and when the genus is given the thorough revision of which it stands so much in need. Although a few species have been assigned to the genus from Australia, Java, and elsewhere in the east, the vast majority are New World forms, and most of them are neotropical. Clavareau records twenty-two species as occurring in Colombia, and the writer has found about a dozen species in the Santa Marta region of the same country.

The genus *Colaspis* was erected by Fabricius in 1801 and may briefly be characterised as follows: Eumolpine beetles in which the front margin of the prothoracic episternum is straight or concave, its internal angle not raised; the tarsal claws appendiculate; the two posterior pairs of tibiae not emarginate on the outer margin towards the apex; the prosternum squarely truncate at the base; the lateral margins of the pronotum dentate or undulate (Colaspites); the anterior femora unarmed; the first joint of the posterior tarsi as long as the next two combined; the antennae not thickened or attenuate apically; and the pronotum narrowed from base to apex. (Adapted from Chapuis, 1874.)

The determination of the insect herein discussed as *Colaspis hypochlora*, Lefèvre 1878, has been made by several authorities including Doctors H. S. Barber and E. A. Schwarz, of the U.S. National Museum. Dr. Barber reports, "Specimens agree with some of those received under the name *Colaspis hypochlora* Lefèvre from the Godman and Salvin collection, but our series shows too great variation to accept all specimens as one species. No better identification can be given at this time, however." Since the type locality given by Lefèvre is Colon, it is probable that the Santa Marta form is typical, and that if the species is found to be composite the new varieties will be those reported from northern Central America and Mexico.

None of the several species of *Colaspis* found by the writer in the Santa Marta region could be confused in the adult stage with *Colaspis hypochlora*, which is described in detail below. Only two others are at all common, *Colaspis lebasi*, Lefèvre, found in the banana fields feeding on a species of *Ipomaea* and occasionally on young banana leaves, and an undetermined species from rather dry localities feeding on the leaves of a prickly solanaceous plant. The only other species collected of which it has been possible to obtain identifications are *C. prasina*, Lefèvre, from Vista Nieve at an altitude of 5,000 feet in the Sierra Nevada de Santa Marta; *C. coneja*, Kolbe, of which three specimens were obtained, a soft adult, a pupa, and a larva, all found among grass roots in an abandoned banana field at Sevilla; and *C. suturalis*, Lefèvre, feeding in some numbers on a common leguminous weed in pastures. For all of these determinations the writer is much indebted to Dr. E. A. Chapin, of the Bureau of Entomology, U.S. National Museum, Washington.

Morphology.

Egg (fig. 1, *e*).

Oval; pale yellow, turning darker as the embryo matures; 0·6 mm. long and 0·25 mm. wide; surface smooth and shining. Shortly before eclosion the anterior pole becomes hyaline and two brown dots mark the position of the mandibles of the embryo.

Larva (fig. 1, *f*).

Length, full-grown and extended, 8·5 mm., diameter 2 mm. Dirty white; the head-capsule amber-coloured; the mandibles brown, deepening to black at the tips; the whole of a dull and greasy appearance, except the head and prothoracic shield which are shining. Wrinkled, with numerous tubercles. Very slightly hairy, the hairs pale except the ambulatory bristles which are brown. Head-capsule distinctly but not markedly bilobed, much narrower than the body, 1·2 mm. wide and a little longer than wide. Mandibles emarginate at the tips. Thoracic legs similar, directed downwards. Second to eighth abdominal segments with prominent ventral tubercles bearing brown ambulatory setae, which extend in a row across the ventral surface of each of these segments.

The newly hatched larva is about 1 mm. long and 0·22 mm. wide; its head-capsule and prothoracic shield hyaline, the remainder of the body pale yellow; much more pubescent than the full-grown larva, having numerous, comparatively long, lateral and dorsal hairs.

Pupa (fig. 1, *b*).

Length, abdomen extended, 5·0 to 5·5 mm.; width 3·0 to 3·5 mm. Dirty white when first formed, but undergoing changes of colouration as it matures. With sparse but comparatively long hairs. The head with five pairs of prominent bristles, two anterior, near the clypeus, one near the posterior margin of the eye, and two posterior, on the vertex. The meso- and metathoracic leg-cases bearing a stout curved spine at the tibio-femoral joint. The elytron-cases distinctly ridged. Apex of the abdomen with three pairs of spines—one apical, stout, curved, pointing posteriorly; one anterior and dorsal to these, smaller, straighter, pointing posteriorly; one situated on a pair of small tubercles just anterior to the large apical spines, much smaller, straight, pointing anteriorly. Notes and drawing from a pupa three days old.

Adult (fig. 1, *a*).

Oval, convex, brown with green iridescence below.

Length 5·0 to 5·5 mm.; width across the elytra at base, 2·4 to 2·6 mm.

Head light brown, the frons rather coarsely punctate and slightly depressed longitudinally in the median line, the depression frequently faint metallic green. Eyes black, inner orbits slightly emarginate. Antennae 12-jointed,* finely pubescent, brown; the seventh, tip of the tenth, and the last two articles piceous; the seventh article slightly enlarged. Labrum emarginate apically. Mandibles short, thick, bidentate.

Prothorax above brown, coarsely punctate, the punctures closer at the sides; anterior margin almost impunctate, of moderate width; lateral margins narrow,

* I am well aware that this group is supposed to have 11-jointed antennae, and have considered the possibility that those of *Colaspis hypochlora* might be 11-jointed with the terminal article only seemingly divided; but the division is so distinct that it seems more accurate to speak of the two parts as separate segments. This character holds in all members of the genus *Colaspis* that I have examined, and also occurs to a varying degree of definiteness in several related Eumolpine genera, e.g., *Metaxonycha*, *Rhabdopterus*, *Prionodera*, *Colaspidea*, *Paria*, *Chrysochus*.

metallic green, more or less obsoletely undulate. Elytra convex, varying from stramineous to fulvous, with nine long and two short rows of coarse, deep, geminate punctures. Epipleural margin metallic green. Thorax below dark brown with green iridescence except laterally on the pro- and meta-episterna. Pro-episternum sparsely

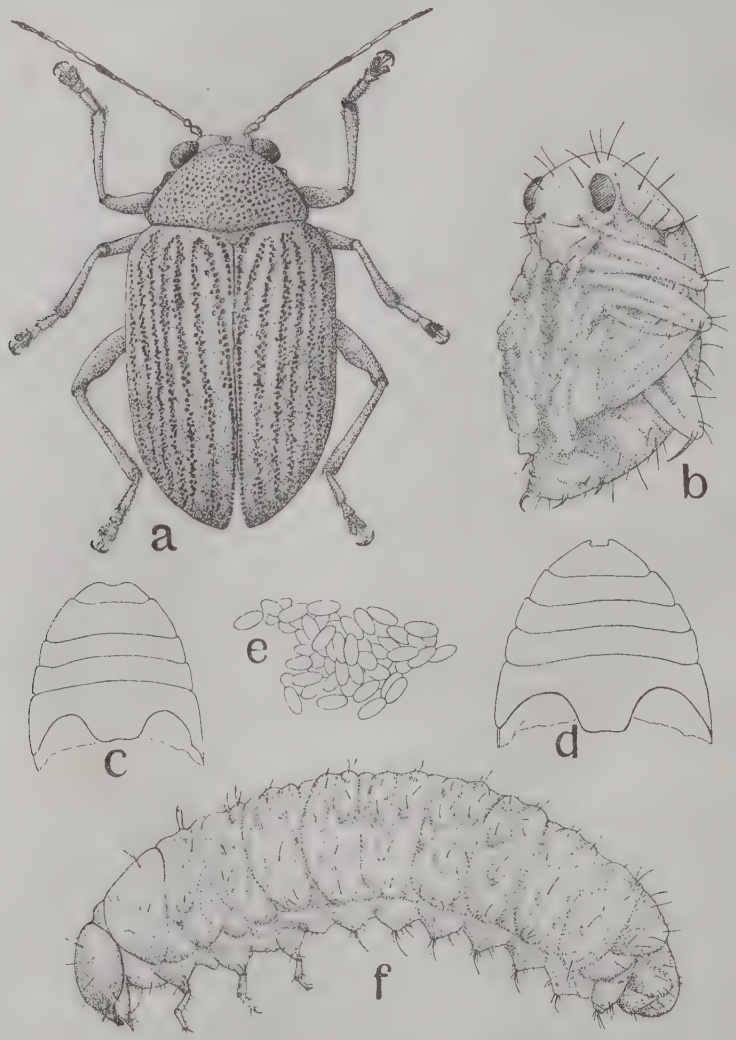

Fig. 1. *Colaspis hypochlora*, Lefèvre : *a*, adult ♀ ; *b*, pupa, three days old ; *c*, abd. sternites, ♂ ; *d*, abd. sternites, ♀ ; *e*, egg cluster ; *f*, fully grown larva. (All figures on same scale.)

but coarsely punctate. Legs stramineous, tarsi and extremities of the tibiae sparsely pubescent ; first article of posterior tarsi about as long as the next two combined ; tarsal claws appendiculate. Hind wings proximally hyaline, distally smoky ; the basal veins amber-coloured.

Abdomen below brown, with dark green iridescence, especially at the base ; with sparse, short, pale hairs. Male external genitalia well chitinized, recurved, boat-shaped. Female ovipositor 4·5 to 5·5 mm. long when naturally exserted, tubular, membranous, strengthened at the tip by thin chitinized rods.

The sexes may be readily distinguished in the field by the shape of the fifth abdominal sternite, which in the male is emarginate apically (fig. 1, *c*), but in the female is distinctly notched (fig. 1, *d*). Moreover, the tip of the female abdomen approximates the elytra and is acute in profile, whereas that of the male falls considerably below the elytra and is truncate. The female abdomen is broader at the base and more triangular in shape than the male abdomen. The antennae of the male are slightly thicker and longer than those of the female. In general, the males average slightly larger than the females ; while the latter, as a whole, have a more contrasting colouration, due to the light ground-colour of the elytra which throws the deep punctures into strong relief.

The beetle is known in Colombia as the " morrocoyita " and has been called by Gowdey (1926) the " banana fruit-scarring beetle."

Oviposition and the Egg Stage.

Oviposition was twice observed under very favourable conditions. In both cases the laying female stood on the soil in a glass jar with the tip of its abdomen against the side, so that the operation above and below the ground was clearly visible. The chitinized fork at the end of the ovipositor adroitly loosens the soil and pushes it to the side to form a small cavity. As the ovipositor is about 5 mm. long and the female takes advantage of crevices in the surface, the chamber lies between 5 and 10 mm. below the ground level ; sometimes, when a crack accommodates the body of the female, as low as 1·5 cm. When the cavity has been completed the eggs begin to pass through the ovipositor, which organ is now dexterously used to put them into position so as to utilise the space to the best advantage. Often the laying is interrupted for a time while the cavity is enlarged or the ovipositor directed towards another part of it. The first female observed laid a total of 118 eggs in the group, the 11th to 118th eggs inclusive being laid in 18 minutes 28 seconds, an average interval of 10·3 seconds between successive eggs. The second female had already laid a number when noticed but deposited fifteen eggs under observation in 2 minutes 13 seconds, or 8·9 seconds per egg.

Thirty-five groups of eggs were laid in the soil of the breeding jars ; thirty groups between 5 and 10 mm. below the surface, three between 10 and 15 mm., and two, when the adult female had crawled under a lump of soil, at an apparent depth of 2 cm. Two groups found in the field were between 0·5 and 1 cm., in each case attached to a root of the grass *Paspalum conjugatum*, Berg.

Eggs laid in the laboratory in the absence of soil may be placed on the leaves and fruit provided as food, but they are never so placed when soil is available. Gowdey (1926) records other situations, none of which was observed in the present study. Judging from the actions of the two females observed laying, the structure and use of the ovipositor, the regularity with which eggs are laid under the surface of soil in the cages, and the finding of two groups of eggs in the field attached to grass roots in the soil, it may well be concluded that the eggs of *Colaspis hypochlora* are normally placed under the surface of the soil at a depth of 0·5 to 1 cm. in small cavities excavated or enlarged by the female.

The two group of eggs found in the field contained 24 and 30 eggs respectively, but groups laid in the laboratory varied between 56 and 230. It was not determined whether a female, having once laid, might lay again after a time.

The duration of the egg stage is given by Gowdey (1926) as 7 to 9 days. In the present study eleven groups of eggs for which definite time of laying and eclosion is

known all hatched six days after deposition. The eggs of a single group hatch nearly simultaneously. The larvae from a group of 250 eggs, which hatched under observation, almost all appeared within an hour, though a few emerged in the second hour and a very few stragglers some two and a half or three hours after the first.

Larval Habits.

Immediately upon hatching the young larvae scatter and begin to burrow actively in all directions through the soil to a depth of about 5 cm. Many come to the surface and spread about over it before finally taking to the ground. They do not eat the eggshells and seem capable of passing the first two days of their life without food. The chief limiting factor at this early stage seems to be the condition of the soil, which must be quite moist. If it is at all dry the larvae soon perish.

Gowdey (1926) records banana roots as the larval food and says that the larvae tunnel in the older roots. In spite of repeated efforts the present writer has been quite unable to verify these observations. Not a single larva has been found within a banana root, or even about banana roots unless grass roots also were present. On the other hand, in all cases in which larvae were taken in the field they were invariably at or near the roots of grass, and, moreover, of a single species of grass, *Paspalum conjugatum*, Berg., known in Colombia as " paja panela." Both groups of eggs found in the field were attached below the surface of the soil to roots of the same plant. Feeding of newly hatched larvae on the epidermal tissues of the roots of this same grass was observed, but the same tissues of banana roots were never seen to be eaten. On one occasion larvae, pupae, and a soft adult were taken from the soil among grass roots, where they must certainly have developed without banana roots, as a deep ditch containing water separated them from the nearest bananas, five metres away. Finally, larvae found in the field have been brought to maturity in the laboratory on a diet of the roots of *Paspalum conjugatum*. The larvae, then, certainly feed on the roots of this grass, whether banana roots also serve or not.

Although grass, if banana roots also are eaten, may not be essential to the larval life of the beetle, a damp soil in which to pass the larval period certainly is. Larvae in the laboratory very soon die if the soil in which they are kept is allowed to become even a little dry. In the field, larvae are always found in damp soil, under the trash heaps, at the edges of drains and ditches, and among the matted grass roots of poorly drained places. In sandy soil, which soon loses its moisture, they do not occur. As will be shown later, this factor may be turned to advantage in control of the insect.

Larvae are usually to be taken at a depth of 5 to 8 cm. in the soil, and this is the depth at which they feed and grow. During an unusually dry period in July and August, 1927, however, no larvae were to be found at that depth, but only much deeper, between 20 and 25 cm. below the surface. At that depth the soil was free from grass roots and no bananas were near, and as one was observed to be lying in a spherical chamber, it may be assumed that the larvae had penetrated lower in the soil to avoid the drying of the upper layers.

When ready to pupate, the larva constructs a pupation chamber in the soil at a depth of 5 to 8 cm. Herein it becomes shortened and thickened and lies inactive. This prepupal stage lasts about two days.

The Pupa.

Pupae are found in situations similar to those of the larvae, in damp soil, at a depth of 5 to 8 cm. When first formed they are completely creamish white, but from day to day various marks appear, so that the age of the pupa can be readily determined. After 24 hours the eyes become very faintly brown ; at 48 hours they are light brown and the colour of the entire pupa is darkened to light cream. On the

fourth day the eyes have become brown and the mandibles tinged with grey ; the next day the eyes are dark brown and the mandibles brown. About twelve hours before emergence the eyes are black, the mandibles dark brown, and the tips of the wing-sheaths grey. Transformation to the adult takes place five to five and a half days after pupation.

Habits of the Adult.

The newly emerged adult is very soft and pale, and, though gradually becoming harder and darker, may still be a little soft four days after transformation. The first day or two after the change is often passed in the pupal chamber underground, the beetle not making its escape to the surface until the body has become harder. Beetles are active and well able to fly, however, long before they are fully hardened ; one readily took to wing only 36 hours after its transformation, and another when only forty-eight hours old ; although both were noticeably soft. The green iridescence on the lower surface does not appear until the adult is one or two days old and is not completely assumed until the fourth or sometimes the fifth day. Throughout this early period the beetle needs very little to eat ; one lived twelve and several nine and ten days after transformation without ever having partaken of food.

The duration of the adult stage probably varies as enormously in nature as it does in individuals under observation. The longest life recorded in captivity was eighty-one days after capture in the field. No differences were noted in the duration of the life of the two sexes or at different times of the year.

The adult beetle is an alert but not an active insect ; quick to escape if actually disturbed, but otherwise moving very little. Although able to crawl up smooth vertical surfaces, it clings but feebly and is easily dislodged. It can walk rapidly and fly well, but in ordinary circumstances seldom takes to wing. Undisturbed, it walks about the stems of fruit or the young leaves on which it feeds, or crawls about the grass stalks on the ground. On approach of danger it hastens to hide, usually simply dropping to the leaves or ground below, but sometimes crawling away to an undisturbed situation or, very occasionally, flying to a plant near by. The observer, silent in the fields, rarely sees one in flight, though the leaves and fruit about may shelter very many.

Flight tests were carried out at three different times with forty beetles, twenty males and twenty females, by liberating them from a vial to the top of a pole, two metres high, in the centre of a large lawn. All demonstrated a tendency to drop quickly to the ground and hide rather than to fly far. The males were noticeably more active and took to wing more readily than the females, most of which had to be urged to fly either by teasing with a pencil or by tapping on the pole. A decided tendency to fly in the direction of the wind was noted. The males flew farther than the females, both on the average and in individual flights. The largest recorded " non-stop " flight of a male was 74·25 metres and of a female 68 m., but both insects were in the air when sight of them was lost. The males flew an average of 28·7 m. on each flight, the females 21 m. Beetles may immediately again take to wing after the first flight, so that they are capable of flying much farther than these figures for single flights would seem to show. After the first few metres, which are frequently traversed in a downward dart, usually erratic, the flight is steady and strong.

As the beetles act individually and demonstrate no social or swarming instinct, migration in the sense of movement *en masse* does not occur. Even in the worst infested area, food is always plentiful, and it is never really necessary for the adult to move on to new feeding places. However, in various circumstances a single beetle may occasionally travel to a considerable distance, or during a strong wind a number may be driven at the same time in the same general direction. In considering such movements of the beetle from farm to farm as might occur, it is essential to recognise

that the permanent effect of the movement depends on two conditions: first, that the beetle shall be a female, and second, that a suitable breeding-place shall be found in the newly invaded area. Should only males participate in the movement or should the females fail to find either mates or suitable breeding-grounds, the species will be unable to establish itself and fruit will be damaged only during the life of the individual. Since the female is the less active sex, less likely or able to fly of its own accord to any great distance, and more likely to drop to the ground and hide if disturbed by strong winds, the chance of any rapid, permanent movement to any considerable distance is further reduced.

It might be claimed that although lack of food never forces a migration, the drainage or drying of an area might lead the female beetles actually to migrate in search of new breeding-grounds. This, however, is very improbable. There are always in the lots small areas of grass growing temporarily in damp soil, beside the drainage ditches and guardarrayas, if not elsewhere, and it is most likely that the females would concentrate at these places to lay their eggs.

Although the epidermal tissues of the banana fruit constitute the chief food of *Colaspis hypochlora* in Colombia, the species also commonly feeds on young banana leaves. These are always attacked while they are still tightly rolled and are scarred in a similar manner to the fruit, only the outer fold and perhaps part of the second being affected.

Apart from the banana, *Musa sapientum*, *Colaspis hypochlora* has been found feeding on the leaves of the following plants: Rose bushes (G. E. Bodkin, 1919), *Lantana camara*, Linn. (F. E. Walker), *Antigonon leptopus*, H. & A. (F. E. Walker), *Boerhaavia erecta*, Linn. (F. E. Walker), *Boerhaavia caribaea*, Jacq. (=*repens*, Linn.) (F. E. Walker), *Heliotropium indicum*, Linn. (F. E. Walker), *Jussieua suffruticosa*, Linn. (F. E. Walker), *Jussieua erecta*, Linn. (F. E. Walker), *Coccoloba* sp. (F. E. Walker), *Terminalia catappa*, Linn. (F. E. Walker and George Salt), *Machaerium humboldtianum*, Vogel (George Salt). In the breeding cages, even in the presence of a plentiful supply of bananas, the beetles also eat the young leaves of the grass, *Paspalum conjugatum*, Berg. Such a diverse diet list suggests that on occasion the beetle might eat many other plants and become, in fact, practically a general feeder.

The scarring of banana fruits by *Colaspis hypochlora* offers an interesting case of insect adaptability. Undoubtedly the species, in common with the other members of its genus, and indeed, of its entire family, was originally a leaf-feeder. Which, if any, of its recorded food-plants was its original food is unknown; and no clue is afforded by the present diet of other species of *Colaspis* in Colombia, which, like the above list, includes plants from various, widely-differing families. One other species, *Colaspis lebasi*, Lef., a species closely related to *C. hypochlora*, was once induced in the laboratory, under conditions of extreme starvation, to scar bananas in a manner similar to the latter species; in other cases it starved to death without attacking the banana fruits provided. Although this beetle, *C. lebasi*, appears to feed normally on a species of *Ipomaea* in the banana fields, it is occasionally found in company with *C. hypochlora* eating the young rolled leaves of banana suckers, and its larvae are found in the soil together with those of the morrocoyita. It may well be that *C. hypochlora* commenced its career of destruction in a like manner, moving, when its original food-plant was cut down to make way for banana plantations, first of all to the young leaves of the bananas, and then, when it had acquired the taste, to the banana fruits. Such a view of the original outbreak is supported by some of the historical facts; the great increase of the beetles in Orihueca district in 1922, for instance, was immediately preceded by rapid felling and planting in the neighbouring Miranda and Cañobobal tracts in the previous year.

The morrocoyita is either attracted or repelled by light according to the circumstances. Efforts at escape are made towards the light, but, on the other hand,

in its normal, undisturbed condition of life, it appears to avoid excessive exposure, prefers shady locations, and bites the fruit on the lower side out of the sun. The beetle eats energetically through the night and feeds on the upper, exposed surfaces of the bananas during the hours of darkness. The influence of gravity on its actions is not especially marked, although, as a rule, the insect crawls upwards.

The adult beetle is not continuously present in the banana fields throughout the year, but occurs in more or less well-defined outbreaks or broods. In Colombia there are normally four broods a year, all of which appear during the rainy season. During the dry season (December to April) adult beetles are almost or entirely absent from the plantations. The first brood makes its appearance soon after the beginning of the spring rains, about the end of April. The second is usually developed towards the end of June; the third normally appears two months later; and the fourth emerges about the end of October. The broods gradually increase in size from the first, which is small and does very little damage, to the fourth, which is the largest and causes the heaviest loss. Each brood remains active on the fruit about four or five weeks, though in gradually decreasing numbers toward the end of its period. During the rainy season there is no very complete break between the broods, and a few beetles of each remain alive until the next has appeared, so that from early May until December it is always possible to find adults. Local conditions and exceptional seasons, of course, cause minor variations in the time of appearance of the broods.

Since no stage of *Colaspis hypochlora* has been found in numbers in the middle of the dry season, it is not definitely known by observation in what stage the beetle passes the period from December to April; but a great deal of evidence makes it almost certain that the season is passed in the larval stage. The final brood of 1926 appeared in October and the first part of November and proceeded to lay its eggs. These hatched and the larvae commenced to feed. Then, in the field, they were lost. The following March no adult beetles having appeared in the meantime, three-quarter and full-grown larvae were taken from the soil in the farms, among grass roots. These observations in themselves are practically proof that the beetle passes the dry season in the larval stage, but further data seem to show how and where the period is passed, and to explain why the larvae were not found during January and February of 1927. It has already been mentioned (p. 300) that during the unusual dry period of July and August, 1927, larvae were found much deeper in the soil than they usually occur and appeared there to be resting in chambers in the soil, without feeding. The action of these larvae affords a clue to the passage of the dry season, and it seems very probable that after feeding for a short time and becoming perhaps half-grown, the November larvae begin to feel the drying of the soil at the end of the rains and to avoid desiccation burrow downwards to pass the ensuing three months in resting chambers at a considerable depth. This habit, and the proximity of the larvae to grass roots, would explain why they were not found by the writer during January and February, 1927, for at that time they were unknown to him and were largely sought in the surface soil about banana mats, where they had been supposed to occur.

It has already been mentioned that the broods gradually increase in size until the last, that of November, which is the largest and most injurious; the outbreak of the following May being again much smaller. The reason for this yearly fluctuation in numbers is probably to be found in the lengthened larval life of the adults appearing in April, which have run the danger of drying (or drowning at times of irrigation) and have been exposed to the attacks of their various enemies for a period of three or four months instead of for only a few weeks.

Distribution.

Colaspis hypochlora has a wide distribution in Central America and northern South America. It has been reported from Mexico, Guatemala, British Honduras, Nicaragua,

Costa Rica, Panama, British Guiana, and Colombia. In the last named country it occurs generally in the lowlands of the Santa Marta region, but has not been recorded from the interior or from west of the Rio Magdalena.

Although generally distributed throughout the Santa Marta banana zone, the morrocovita is especially prevalent in certain places. Surveys intended to determine the localities of greatest abundance were commenced early in the present study, and it was very soon found that certain sets of conditions were invariably accompanied by a severe infestation. Unfortunately, the actual infestation figures are not for publication and general statements must suffice.

Viewing the banana zone as a whole, it is immediately noticeable that the parts suffering severest injury are those low-lying districts in which the drainage problem is particularly difficult; thus the lower farms of the Tucurinca district and the north-western parts of Sevilla are clearly centres of infestation. In all parts of the region the correlation between the percentage of the fruit scarred and the proximity of slowly-flowing streams is remarkably clear and definite; even quite small ditches, if blocked or not properly drained, show a decided concentration of injury beside their courses. Areas which have been abandoned after a period of cultivation and in which the grass and bush has grown and the drainage system become choked are also centres of infestation, and as one approaches their borders through the banana fields there is a striking increase in the proportion of scarred fruit and the amount of scarring on the individual bunches. In the course of cleaning experiments another centre of beetle distribution became apparent; when areas of a considerable size were continuously subjected to specially clean cultivation beetle injury was found to be confined to the edges of the grassy boundary roads or to small, uncleaned, grassy places within the lots.

Since the adult beetles can fly and are perfectly capable of scarring fruit away from the situations enumerated above, it becomes necessary to explain the existence of these very definite centres of infestation. A consideration of the sluggish habits of the adult beetles affords the clue. The beetles feed mostly near their breeding-places, and the distribution of the scarred fruit is really dependent upon the distribution of the larvae.

The significance of the various centres of infestation becomes at once apparent; poorly drained farms, beside grassy streams and ditches, near abandonments, along grassy roads, and at low, grassy places within the lots, all have in common a damp soil and frequently a growing grass, which are factors already shown to be essential to the larval stage. In these same situations exactly the larvae have been found, and not elsewhere. Adult beetles may exist perfectly well and scar fruit in high and dry situations, but such places are never badly attacked, and as the larvae do not occur there they cannot be perpetually infested. For practical purposes, then, the distribution of the beetle in the fields is strictly dependent upon the distribution of the larva; a limitation which may be made of excellent use in control.

Natural Enemies.

Very few natural enemies of *Colaspis hypochlora* have been reported. None is definitely known to attack any of the immature stages, but undoubtedly they are preyed upon by various forms of predacious beetles, ants, lizards, and birds. Attid spiders were reported by Mr. F. E. Walker (in his Annual Report to the United Fruit Company for 1925) to feed upon adult beetles, and this was once observed in the present study. Examination of lizard excrement from about banana suckers has shown that these reptiles frequently include *Colaspis hypochlora* in their diet, and Walker (*loc. cit.*) reported finding remains of the morrocovita in the stomach of a tree-frog. None of the recorded natural enemies, however, seems to be of primary importance in controlling the numbers of the beetles.

Control Measures.

At the present stage of our knowlege of its natural enemies, biological control of *Colaspis hypochlora* is not feasible. None of the recorded natural enemies of the beetle is of great importance, and although birds, lizards, frogs, and spiders may account for large numbers of the adults and various subterranean predators probably take toll of many larvae and pupae, such organisms have too wide a host range to act as controlling agents. The possibility of obtaining useful parasites cannot be estimated; nothing is known of them at present, and they would have to be sought and studied in the various countries in which *Colaspis hypochlora* or its near relatives occur.

Artificial control of the immature stages, using poisonous gases or fumigants, seems to be impracticable. Not only is there great difficulty in applying such poisons as carbon bisulphide, hydrocyanic acid gas, or paradichlorobenzene, to the soil over large areas, but also the larvae and pupae are found only in heavy, damp soils, and in these, on account of their impermeability, gases are least effective.

Four classes of substances might be used in attempts at artificial control of the adult beetle; poisonous gases, repellent chemicals, contact insecticides, and stomach poisons. To use gases against the adult would necessitate enveloping the growing bunches, temporarily, one by one, in some form of a container. The difficulty of carrying on such a procedure throughout a region which produces annually some ten million bunches of bananas is obvious. Moreover, as the gases would immediately diffuse when the covering was removed, the fruit would be left unprotected and liable to further attack at once.

Repellent chemicals sprayed upon the growing fruit would not reduce the numbers of the pest, and would afford only temporary protection, since as soon as the material evaporated or was washed off by the rain, the beetles would no longer be deterred.

To combat the morrocoyita with contact insecticides, it would be necessary to apply the poison to the bunches of fruit where the beetles feed. This procedure would present a grave difficulty, namely, that a solution sufficiently strong to kill the beetle on contact would be far too concentrated for the plant; loss as a result of burning would simply replace loss from scarring. There is, however, a small class of contact insecticides, including pyrethrum and derris, to which this objection would not apply. No data are available on the effect of these substances on the morrocoyita, but it is possible that they might afford an effective control; at any rate, they deserve investigation.

Stomach poisons are most commonly employed in the control of insects, like *Colaspis*, of the biting type. In the years 1923 to 1925, much experimental work was done in Colombia by the writer's predecessors on the effect of stomach poisons on the morrocoyita. The results of experimental dusting with calcium arsenate were not such as to warrant its adoption, and in the actual attempts at large scale control made by the United Fruit Company in 1926, arsenate of lead was applied as a spray. Various formulae and concentrations were used, but the mixture eventually considered best and adopted over the entire area was composed of 1 lb. of lead arsenate and 1½ lb. of whale oil soap to 50 gallons of water. This material was applied in some farms from knapsack sprayers, in others from pressure tanks transported on mule-back. The necessity of applying the poison to the fruit proves to be a serious objection in a country where native labour must be entrusted with the control work, for the spray mixture is often wrongly made or not kept sufficiently agitated, and much fruit may be ruined by burning before the mistake can be detected.

The writer's first task in Colombia towards the end of 1926 was to review the spraying campaign and determine its result. His findings may not here be described in detail, but the general conclusions may be given. The treatment was quite ineffective. The spray mixture was readily washed off by the rains occurring almost

daily during the beetle season, and the spraying of the fruit frequently so disturbed the beetles that they moved to other bunches or to other food-plants, returning to feed upon the sprayed bananas later, when the rains had rendered them innocuous. Indeed, it was concluded, on the basis of surveys of sprayed and unsprayed areas totalling several thousand acres, that the spraying was actually increasing the damage by keeping the otherwise sedentary beetles in motion and causing the same or a smaller number of beetles to scar a larger number of bunches. The campaign was therefore abandoned at the end of 1926.

Although as a general rule the stomach poison must be applied to the bunches of fruit on which the beetles feed, in replanted areas where the beetles often occur in numbers on the young rolled leaves of the suckers, the poison may very well be sprayed on the young plants. Here the danger of seriously burning the plant is much reduced and a mixture sufficiently concentrated to cause the speedy death of the beetles may be used with impunity. This practice, however, is of very limited application and value. The use of baits or trap crops which might be mixed or sprayed with stomach poisons would also permit their greater concentration. However, no plant which is sufficiently attractive to the beetle to act as a trap crop is known, and while a few experiments carried out by the writer with a bait of crushed or ground green bananas gave fair results in the laboratory, the efficacy of the material in the field is much to be doubted.

Normal control includes such simple mechanical means as collecting the adults in traps (suggested by Mr. Gowdey in 1923) or bagging the fruit (suggested by Mr. Walker in 1925); and cultural methods such as cleaning, draining, burning trash, or any such agricultural practice. The former class may be readily disposed of. Used on a small scale at the beginning of an outbreak or in a very limited area, collecting the adults might be an excellent method, but at the present stage of the infestation in Colombia it would be weak and ineffectual. Bagging the fruit not only would be a costly and difficult performance, but also, like repellent chemicals, would simply avoid injury while not reducing the infestation and would necessitate a continuance of the process year after year.

Cultural methods, the last group to be discussed, in the opinion of the writer and in the light of all available facts, affords the best, and perhaps the only, practicable control of *Colaspis hypochlora*. The banana fields of the United Fruit Company in Colombia are normally cleaned four to seven times a year, depending on the growth of grass and weeds and on the type and thoroughness of the cleaning done. All the land being under irrigation, with innumerable small conduits and drains, cultivation of the soil by machinery is impossible and cleaning is done by hand, with machete or shovel, the latter being by far the more thorough tool. Surplus irrigation water in the dry season and rain in the wet is carried off by a network of drainage ditches, consisting of numerous small laterals and larger drains leading to the main canals. All of these, naturally, are placed on low ground and being continuously damp, harbour a growth of moisture-loving grasses which soon overgrow the smaller ditches and stop up the drainage if not frequently cut down. The clearing of the ground of grass and the maintenance of the ditches in a functional condition is a common and necessary farm practice throughout the Santa Marta region, and it is this process of cleaning which seems to offer an excellent method of control of the morrocoyita. Before adducing the evidence of the efficacy of cleaning in control, however, it will be instructive to review the biological and distributional facts which suggest its use.

In a previous place (p. 304) it was pointed out that the distribution of the beetle is strictly dependent upon the distribution of the larva. But a damp soil, and possibly a growing grass, has been shown (p. 300) to be essential to the life of the larva and to limit its distribution. The moisture content of the soil, therefore, and possibly the presence of a grass, constitutes a limiting factor in the distribution and prevalence of the beetle. Such a limiting factor affords a most satisfactory point of

attack. The larval stage, moreover, is an excellent one to combat. In this state the insect is soft and unprotected and comparatively immobile, the area of its distribution is more restricted than that of the adult, and it has not yet commenced its career of destruction.

Evidence that cultural control might be very effective comes from three sources : a review of the course of the infestation in Colombia for the past four years, a consideration of the present distribution in relation to well-kept and poorly-managed farms, and the results of field experiments.

The general reduction of the infestation throughout the Santa Marta banana zone from the years 1924 and 1925 to 1927 can only be attributed, in the opinion of the writer, to improved cleaning and draining. That a reduction, and a very considerable reduction at that, has taken place since 1925 is well known. The comparatively small amount of spraying that was carried on in 1926 will not explain the improvement, nor has any natural enemy or disease brought it about, and with the easy elimination of various other minor factors, change in soil conditions alone is left to account for the decrease. This, after all, is the most probable cause. The year 1924, in which the beetle made rapid strides towards its peak, was an exceptionally wet year ; the heavy rains not only provided large areas of damp soil to act as breeding-grounds, but also hindered the labourers in their work of cleaning. Since that year the rainfall has been more normal, the drainage system of the zone has undoubtedly been gradually improved, and it seems reasonable to assert that methods of cleaning and its thoroughness have also gained.

The notably low infestations of well cleaned, well drained farms, as brought out in the distributional studies previously mentioned, is further evidence of the effect of good cultivation.

Finally, there is the virtual proof of the possibility of cultural control to be derived from the results of a series of field experiments carried on by the writer from May to October, 1927. Two areas, each consisting of twelve lots, and containing 435 and 180 acres respectively, were used for these experiments, which consisted simply in keeping one half of each area as free from grass as practicable with all the drainage ditches clean and functioning; while the remaining, entirely comparable half was treated as a control, being kept in about the usual condition of the farms of the region. Nearly the same amount of cleaning was done on the two halves, but while the control lots were cleaned as usual with either shovel or machete, the special areas were done entirely by shovel-cleaning, which is more thorough, lasts longer, and is more expensive.

The experiments were not begun until May, and by the time the first cleaning was completed the May brood of beetles had already emerged and scarred fruit in both clean and control lots. This obscured the results for the first few months, but by the end of October the beneficial effects of the cleaning were very apparent. At the beginning of June the cleaned lots of the first area had an initial infestation (as shown by the percentage of fruit scarred) nearly twice that of the controls, but at the end of October the infestation of the cleaned part was less than half that of the uncleaned. The cleaned half of the second area had a slightly lower infestation than its control in June, and by the end of October this difference had greatly increased so that the injury in the special lots was only slightly more than a third as heavy as in the others. The figures, unfortunately, may not be published. Excellent as these results are, it is felt that they might have been much better had the treatment been commenced in time to affect the May brood, and had the cleanings been more carefully timed to catch the broods in the larval stage.

In view of the considerable amount of evidence, direct and circumstantial, biological and agricultural, that has been accumulated on the subject, there is no room for doubt, in the opinion of the writer, that cleaning and draining have very beneficial

effects on the beetle infestation. Of the two, the correction of soil moisture by drainage is to be considered a more important method of control than the mere riddance of grass by cleaning. The former may be looked upon as the actual or permanent control for large areas, the latter as an ameliorative treatment. Drainage acts directly by reducing the unnecessary moisture content of the soil and rendering it unfit for the larval stage ; cleaning may act directly, if grass is absolutely necessary to the larval stage, and at any rate acts indirectly, assisting drainage by exposing the surface layers of the soil, in which the larvae live, to the air and allowing them to dry.

How much cleaning and draining must be done to give good results is not definitely known. It will vary from place to place and from time to time. It has been observed, however, that after the first few thorough cleanings both the cost of an individual piece of work and the necessary frequency of the cleaning is reduced. In well cultivated soil the harmful, matting grasses, especially *Paspalum conjugatum*, do not readily grow ; instead there appears an open and innocuous growth of *Tradescantia* and sometimes *Boerhaavia*. The cleaning should be carried out just previous to and during the height of the larval brood to do the most good, and, indeed, it may well be that in all but the worst infested areas no extra cleaning will be necessary, but merely a synchronisation of the normal cleanings with the height of the larval brood.

In summary of the subject of control : Biological control of *Colaspis hypochlora* remains uninvestigated, and its possibilities unknown. The different forms of artificial control offer various, sometimes insuperable difficulties of application ; most of those that are possible have undesirable aspects in that they endanger or do not protect the fruit ; all involve special and costly operations ; and, on trial, artificial control has failed. Cultural control is easy of application, involving no special practice, but only an improvement in the most common farm operations ; it catches the insect at the most suitable and economic period ; it has beneficial secondary effects on the production ; and, on trial, it has proved itself a success.

To carry on the control of *Colaspis hypochlora* in Colombia the following recommendations are made :—

(1). The ground should be well drained ; drainage systems should take care of large, low-lying tracts of land, and the smaller ditches should be numerous and kept clean and functional.

(2). The banana fields should be kept clean and as free as possible from grass and weeds which form a close cover. Shovel-cleaning should entirely supersede machete-cleaning. Cleaning should be done at the optimum time ; farm overseers should be notified in advance of the appearance of the larval broods and should arrange to do most of their cleaning, at any rate in badly infested areas, at that time.

Literature Cited.

Bodkin, C. E. 1919. Notes on the Coleoptera of British Guiana.—Ent. Mon. Mag., lv, pp. 210–219, 264–272 (*Colaspis hypochlora*, p. 270).

Chapuis, F. 1874. Histoire Naturelle des Insectes. Genera des Coléoptères (Lacordaire & Chapuis), x, Phytophages.

Clavareau, H. 1914. Coleopterorum Catalogus (Junk), pt. 59, p. 28.

Fabricius, J. C. 1801. Systema Eleutheratorum, i, p. 411.

Gowdey, C. C. 1926. The banana fruit-scarring beetle (*Colaspis hyperchlora*, [sic !] Lef.).—Bull. Ent. Res., xvii, p. 137.

Jacoby, M. 1881. Biologia Centrali-Americana, Coleoptera vi, pt. 1, p. 138, pl. vi, fig. 18.

Lefèvre, Ed. 1878. Voyage de M. E. Steinheil à la Nouvelle Grenade. Eumolpides.—Mitth. Münch. Ent. Ver., ii, pp. 112–133 (*C. hypochlora*, p. 123).

TSETSE-FLY (*GLOSSINA MORSITANS*) IN THE KOALIB HILLS, NUBA MOUNTAINS PROVINCE, SUDAN.

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(Plates XIV–XV.)

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1. General Description of the Fly Area.

The general conformation of the Nuba Mountains Province is that of isolated groups of rocky volcanic hills, which have the general appearance of vast piles of boulders, rising abruptly from a gravel soil plain. The latter slopes away gently to meet the surrounding badobe soil at distances varying from one to five miles. Smaller outcrops of rock are dotted over the gravel plains. The fly area comprises one such group of hills, lying between longitudes 30° 15′ and 30° 30′ E., and latitudes 11° 30′ and 12° N., and forming a narrow broken line, twenty miles long from north to south and three miles from east to west at the widest point. Towards the southern end they are higher and more extensive.

The hills themselves are sparsely dotted with a variety of trees, amongst which *Ficus* spp. predominate, and the gravel soil close to the hills carries large shade trees, such as *Adansonia digitata* (tebeldi), *Acacia albida* (haraz), *Ficus* spp., *Cordia abyssinica*, *Balanites aegyptiaca* (heglig), and a variety of thorny shrubs, and in places long grass four to five feet high. Further out, the larger trees are restricted to the banks of flood khors, which as a rule contain water only in the rainy season, though sometimes muddy pools remain during the dry season. Other pools occur at varying distances from the hills during the dry season, being supplied by rain-water that percolates under the hills and comes to the surface again at some distance, these pools being frequently more extensive in the middle of the dry season than at its inception.

The gravel soil carries shorter grass and herbage, not more than a foot or two high, and bush of varying density, none of which reaches a great height, with several kinds of creepers, which climb over such species as attain the size of trees. Almost all the trees are deciduous, their active period of growth being from May to November, which corresponds with the annual rains, after which this and the other types of country are all liable to be swept by grass fires, particularly the cotton soil, which carries very long grass, dotted with *Acacia talh* (red talh), a tree that affords but little shade.

The Koalib Hills* are separated by a bare ten miles in a straight line from the foot-hills of the Alleira group to the S.S.E. (see map) the larger hills of which are similar

* Referred to in Professor R. Newstead's " Guide to the Study of Tsetse-flies " as the Kuwalik Hills, S. Kordofan.

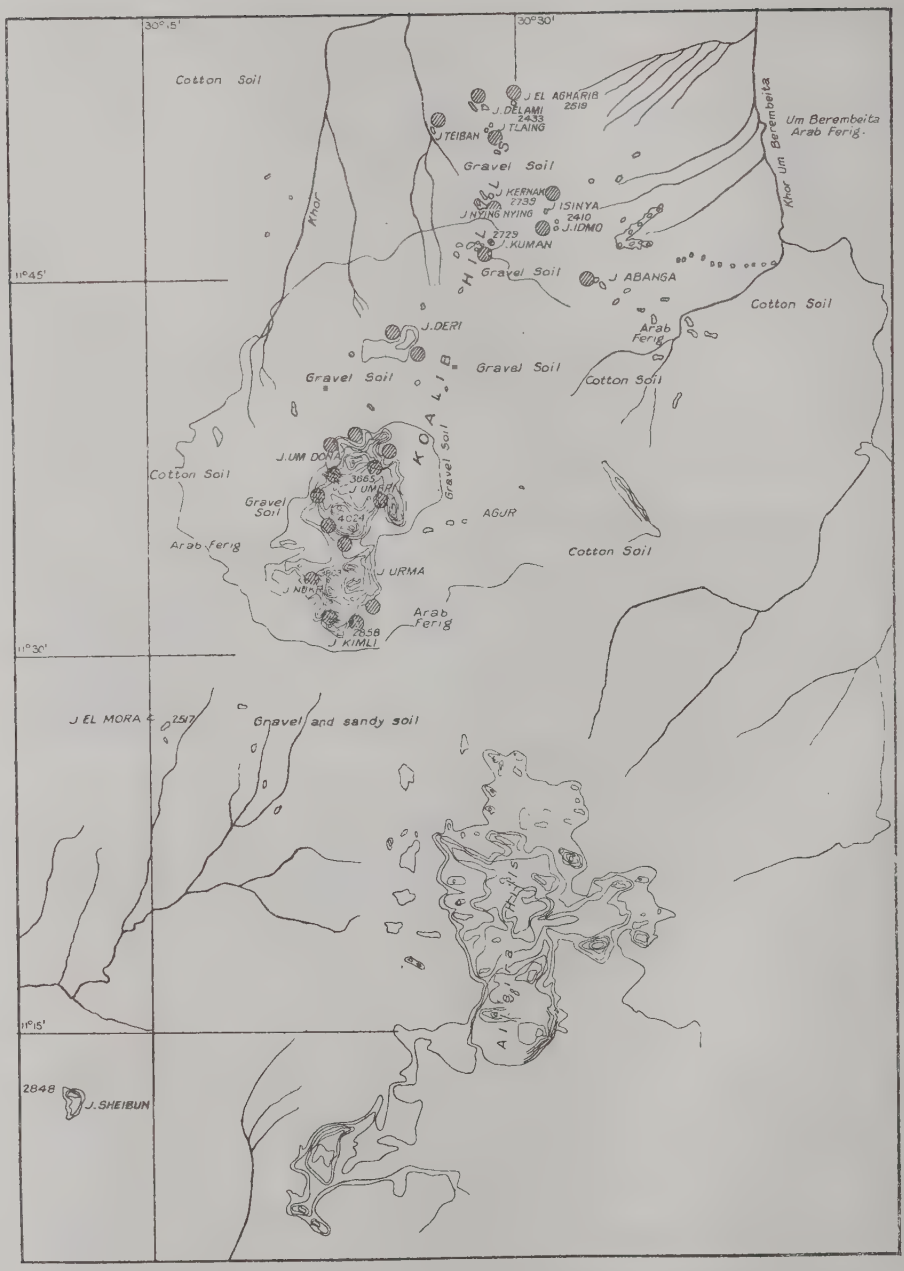

Fig. 1. Sketch-map of the Koalib and Alleira Hills ; shaded circles indicate the presence of *Glossina morsitans*.

in formation to the Koalib, yet no fly has ever been recorded from them. *Glossina morsitans* is known to occur as far north as Wau in the Bahr el Ghazal Province, distant nearly 300 miles from the Koalib, but it may occur on the Bahr el Arab, about 200 miles south-west of the Koalib, an area which has not been investigated for fly.

The Koalib Hills lie in the belt having between 700 and 800 mm. annual rainfall, distributed over a rainy season that lasts from May to October.

2. Inhabitants and their History.

The local inhabitants are chiefly Nubas, a primitive, Pagan, Negroid race, who have only recently found it safe to live and cultivate at any distance from the fastnesses of the hills. There they originally lived in comparative safety from raiding Arabs, who then, as now, came down from the northern province of Kordofan in the dry season to graze and water their cattle outside the limits of the dangerous fly-area, establishing themselves in temporary villages, called "ferigs," near the outlying water-holes. In the past, certain sections of the Arabs were friendly with the Nubas, though about 1889 the Amir Abu Anga attacked the Koalib, but was unable to subdue the main southern groups, owing to the presence of the fly. Within the last ten years the British administration has restrained the Arabs, so that but few Nubas now remain in the upper valleys, the majority living at the foot of the hills, or at a short distance from them. A number have also moved to small rocky outcrops at distances of several miles from the range, such places being selected in preference to an entirely level situation. It seems clear that the Nuba tribes were long isolated each in its own group of hills, since the languages in different ranges are usually entirely distinct, some variation even occurring within the Koalib itself, although those of the Koalib and Alleira tribes are merely dialects of the same language.

3. Wild Fauna.

At the present time the larger animals are almost extinct within five to ten miles of the hills. The fauna of the hills themselves consists of a few herds of baboons (*Papio anubis*) and red huzzar monkeys (*Cercopithecus pyrrhonotus*) in the southernmost hills. Grivet monkeys (*C. aethiops*) are generally distributed and fairly abundant in the same area, and *Hyrax* is to be found in all the hills. Only two species of birds need be mentioned as inhabiting the hills, namely guineafowl (*Numida meleagris*) and rock bantams (*Ptilopachus petrosus*). The absence of vultures might be attributed to the fact that the Nubas are not particular about the quality or freshness of the meat they eat. A few duiker inhabit the valleys of the southernmost area and the gravel soil bush, and occasionally oribi and gazelle occur at two or three miles distance and on the cotton soil beyond, where a few roan antelope and tiang are found; and farther out giraffe still survive. The older Arabs record elephant and buffalo as having existed about fifty years ago, both to the east and to the west of the hills, at which time the surface water supply in the dry deason seems to have been more extensive. The disappearance of game may be attributed to this decrease in water, and also to the acquisition by the Nubas of many old Dervish Remington rifles.

4. Domestic Animals.

The Nubas keep, chiefly as a form of currency, small races of cattle, sheep and goats, which are resistant to trypanosomiasis, though when bred outside the area they are said to lose this quality (Pl. xiv). Small black pigs are also kept, but these and dogs are susceptible, though a number survive. In the dry season the Arab cattle from Kordofan come to within a few miles of the hills, and they and the Nuba cattle may may often be seen drinking together at the outlying waterholes, which are considered to be free from fly.

5. History of the Fly.

As recorded above, the fly appears to have been present about 1889 in the Southern Koalib, which comprises the largest mass of hills, but not in the Northern Koalib, nor in the surrounding bush, there being good evidence to support the theory that more recently the Nubas of the Northern Koalib introduced fly from the southern hills of the group as a protection against the Arabs. Previous to 1889, at the time when the older Arabs say that there were elephant and buffalo in the district, they further state that tsetse-fly was found in association with the game in certain parts (*e.g.* Um Berembeita on the east and between Jebel Sheibun and Jebel El Mora on the south-west), though their evidence on this point is open to some doubt. A more definite case is reported from Abu Gebeiha, about 70 miles east of the Koalib, where in about 1890 fly is stated to have been abundant in association with game near some small hills and to have caused losses amongst the Arab cattle, which had not previously penetrated there. The Arabs took heavy toll of the game, and in the following years it was very scarce and the fly disappeared entirely. Though nothing can be stated for certain, it seems likely that the fly did at one time exist all over the district, and that for some obscure reason it managed to survive the game in one place only, by adapting itself to the changed conditions. Other theories put forward locally are that the fly was brought up from " the South " in gourds filled with blood, but this almost certainly refers to the bringing of the fly from the Southern to the Northern Koalib. Another theory is that about 100 years ago a herd of buffalo came through from farther south and brought the fly with them, which, assuming that the limits of the southern fly belt were the same then as now, seems very unlikely, considering the distance that would have to have been traversed. Whatever the origin of the fly, it has now developed habits greatly differing from those recognised as typical of *G. morsitans* elsewhere.

Although the presence of the fly had been known for a long time, for political reasons it had not been possible to investigate it until recently. With the development of the district, the fact became important by raising difficulties over animal transport, official as well as commercial. The question arose whether the fly might not extend its range under the new and peaceful conditions of the inhabitants, and the present area being moreover comparatively small and isolated, it had also been suggested that it might be possible to exterminate the fly throughout. A survey of the infested area and a general study of the bionomics of the fly were begun in February 1927 and continued until the end of March 1928, the results of the investigations being recorded below.

6. Distribution and Incidence throughout the Year.

(*a*) *End of the Dry Season* (*March to mid-May*).

By the end of March 1927 the general survey of the fly area was completed (fig. 1). The fly was never found, except as occasional wanderers, at any distance from hills inhabited or frequented by Nubas or their animals (Pl. xv, fig. 1, 3) ; but though many of the small outcrops of rock to the east of the range are inhabited, only three were found to harbour fly, a few others having been infested in past years for short periods only. It seems that a small hill, recently infested, will at first carry a relatively large fly population, but that after a few years this diminishes, or disappears altogether ; this does not, however, apply to the main southern hills. To give an example (of the former), the Delami group was free from fly up till 1924, though the older Nubas say that it was present about 25 years ago, when it was exorcised by an Arab " fikki " (holy man). The District Commissioner, Captain Vicars-Miles, states that in 1924 the fly arrived first at Jebel Tlaing (part of the Delami group) owing to the mixing at the grazing grounds of cattle from Jebel Kernak (then a heavily infested hill), and from Tlaing it spread to the north-east of Jebel Delami itself, and finally

to the north-west end over a short stretch of open ground, this north-west rock being by far the most, and Tlaing the least, heavily infested in 1927.

Until the end of March 1927, the weather had been cold, and the fly was little in evidence ; thereafter it became warmer, and more fly were seen, and they showed a tendency to wander, following humans and animals (a similar tendency was noted from November onwards), but in spite of this there was no definite spread from the winter haunts.

(*b*) *During the Rains* (*June to October*).

The first heavy rain fell about the middle of May, but in Delami there were few other heavy falls between this and the end of July.

Despite the remarkable statements of the Nubas, earlier in the year, that the fly disappears entirely during the rains, it showed no marked decrease in any of its haunts, except at Delami, where this was due to the experiment of direct control, to be mentioned later. In the main jebels, Umbri and Um Dona, fly was still as abundant at the end of June, end of July and in August, as at the end of March, though on the other hand there was no sign of its spreading to the surrounding gravel plains. Although Nuba cattle at Um Dona were frequently inspected during a fortnight in August and all through October, during which time they usually grazed near to the jebel, but still went out into the bush for a mile or more on fine days, no fly was ever seen on them whilst in the bush. Occasionally one was seen when they were in the open at a distance of a few hundred yards from the foot of the hill, but it did not remain on them and seemed uneasy. The fly would almost certainly extend out to the limit of the range of the cattle if dense shade and shelter from the wind were continuous from the jebel ; but this is never the case around villages, most of the larger trees and bush having been cut long since for firewood, or tree grazing for goats, and the land cultivated (Pl. xv, fig. 6). At Um Dona the normal range of the fly does in one place extend 300 yards out to the edge of a thicket which is continuous from the jebel and is frequented by cattle, though situated at some distance from their village.

From the end of September the fly became more numerous, or at any rate more in evidence ; *e.g.*, on 3rd October about ten flies were found together on one cow. The general distribution remained the same, with a slight tendency to follow, but these fly were uneasy and took every opportunity to return to the jebel. The fly was once noted as active during the fine rain that followed a heavy shower, and also when afternoon showers had stopped.

(*c*) *Early Dry Season* (*November and December*).

The wind, which during the rains blows from the south, settled to the north at the end of October, but day temperatures were still high. The fly continued numerous in the same haunts, but was more inclined to follow, and to remain singly here and there, in the shade of large trees at those water-holes near the jebel which were frequented by Nuba cattle. The wind is less strong in the evening, and at that time the fly is more inclined to follow. The cattle, which at this period of the year are less frequently grazing about the edge of the jebel by day, are returning thither in the evening, and hence there is little chance of fly being carried by them ; though a few, particularly females, which cling to the shade of clothes, etc., more than do the males, may be carried by humans.

It may be mentioned here that the District Commissioner informs me that a fly is now sometimes taken in his office in Delami after the hearing of a case, which he attributes to the wearing of more clothes by the Nubas during the last few years.

(*d*) *Mid-dry Season* (*January and February*).

In February 1927, the fly was distinctly scarce, but the very opposite has been the case in January and February 1928, when it has been noted at Um Dona in larger

numbers than at any previous period, a following swarm of nearly twenty fly being attracted to humans or animals in the evening; hardly a fly appears in the same places in the early morning when the wind is cold and strong, and at midday it is also comparatively scarce.

7. Food of the Fly and Source of Trypanosome Infections.

The fly feeds chiefly, if not entirely, on the Nuba livestock: cattle, sheep, goats, pigs and dogs, and also to a considerable extent on the Nubas themselves, in places being so closely associated with them in the unsavoury environment of their villages as to merit its being termed a domestic fly (Pl. xv, fig. 4). In Jebel Delami, where there are now no cattle, the fly must depend largely on pigs, and to a lesser extent on Nubas, sheep and goats; but where cattle are numerous, they are the principal source of food outside the immediate vicinity of the villages. An alternative possibility is the small number of duiker in valleys not much frequented by Nubas or their cattle, though nowhere has a fly been found where no tracks of cattle were seen and where duiker were probably present; the same applies to the small water-holes amongst rocks, high up in the hills, where the baboons drink. Moreover, a water-hole in the heart of the jebel ceased to harbour fly when cattle left off visiting it after the onset of the rains. The case of the grivet monkeys is different, since they habitually descend to the foot of the jebel in the fly-infested valleys to feed on the fruits of various trees.

A number of blood-smears of the gut-contents of fly have been taken and handed over to the Government Bacteriologist, and the percentage of fly with fresh blood showed a decrease towards the end of November, possibly to be correlated with the changed habits of the cattle, *i.e.*, grazing farther from the jebel. The work on trypanosomes is outside the scope of this paper and will be published later by the Bacteriological Section, but it may be mentioned here that trypanosomes have been found in the salivary glands of the fly and in the blood of a number of Nuba cattle, goats, sheep and pigs.

8. Proportion of the Sexes.

Approximately equal numbers of the sexes were killed (775 in all) in the Delami group between April and July 1927, but this result was obtained by searching all possible resting places of gorged female flies. In the main hills resting flies are hard to find, and in June only a few females were attracted to humans, while in August no females were seen there, and only one male attempted to bite, suggesting that there was an abundant food supply. By September a few females were being attracted to humans, and the proportion increased later, at times comprising 20 per cent. of a catch; a higher percentage was always obtainable by taking feeding fly on cattle.

9. Breeding Haunts of the Fly.

Eleven puparia were found as the result of about three months' sifting of soil, but of these two only were full (30.xi.1927 and 3.xii.1927). All were in the shade of overhanging rocks at the foot of the jebel, in soil which was loose and friable to a depth of an inch or more, but which left a large proportion of gravel when sifted. Nine were found in one group of boulders which formed a small cave frequented by Nuba cattle at Um Dona (Pl. xv, fig. 2) and in positions where most of them would never be reached by direct sunlight at any time of the day.

Gravid females were at various times found in similar places, and also low down on tebeldi and other tree-trunks, and under the eaves of mud-walled, thatched huts and grain-stores in Nuba villages.

Larvae are also probably deposited in the shade of thickets at the edge of the jebels, but only where the fly is found at rest in numbers regularly are puparia likely to be found; for instance, on one occasion eleven females and two males were taken

thus, all gorged, on or near a large boulder, in the shade of which several Nubas were sitting or sleeping ; but no puparia were found there, and on subsequent days, in the absence of the Nubas, only a few flies were seen.

The length of the pupal period in October, when the weather was hot, was 28 to 29 days for a bred puparium, a male emerging, while the two full puparia above-mentioned gave adults on 19th December, so were probably deposited about 18th November.

10. Experiments undertaken.

(*a*) *Direct Method of Control.*

Owing to the comparative scarcity of fly in the Delami hills early in 1927, an attempt was made to exterminate it between April and July, the method chosen being to employ a gang of about ten small boys, each armed with a wire "fly-swat" and a spirit bottle. The gang searched daily all the possible resting places of fly and also killed any fly attracted to themselves or to animals; the resting places yielded the bulk of the catch and the majority contained fresh blood. The sex-proportion was noted each day ; in the total of 775 flies killed, the sexes were approximately evenly represented. All the females were dissected to see if they contained larvae, and of what approximate size ; it was found that after 10 days of the campaign the proportion of female flies with larger larvae fell from 1 : 5 to 1 : 30. Thereafter, the fly being scarcer, the boys did not work so well, and the proportion rose again. All but 100 of the total 775 flies were killed in the north-west section of the Delami hills, and this represented the relative abundance in the different jebels of the group.

The experiment was abandoned in July, owing to the thick vegetation caused by the rains, and it was possible to observe the effect during the following months, fly again being in evidence at the end of August, but still much reduced in numbers.

It appears that Jebel El Agharib, an outlying hill at the north-east corner of the group, has for the first time become infested since the onset of the rains of 1927, presumably by fly carried accidentally from the nearest infested hill a mile away, originating a population which by the middle of December was comparatively numerous for one of the smaller, northern hills.

Conclusions drawn from the result of this experiment are that in a small isolated area the method reduced the fly to a minimum, beyond which it is doubtful if it would be possible to go, owing to the female flies having a plentiful food supply, and ample and sometimes inaccessible shelter amongst the piled boulders. The few survivors supplemented by any carried accidentally from other hills, serve, during an interval of a few months, to repopulate the area worked, thus making it no more than an effective routine method. In a larger area, like the Southern Koalib, the method would be impossible owing to the extent of the resting places available for the gorged flies.

(*b*) *Trapping with Lime.*

A few preliminary experiments were made with "fly-lime" consisting of resin dissolved in castor oil by boiling, but the results were unsatisfactory.

The lime was, in the first experiment, spread on white cotton cloth and the latter placed on the belly of a cow, being held in position by strings tied over the animal's back. Contrary to their usual habits the fly did not alight on the underside of the cow, but high up on the flanks and neck, where there was no limed cloth.

In another experiment leggings of stout paper were covered with the lime, the wearer then going into the fly area. It was noted that though only a few fly were taken, most of these were on brown as opposed to white paper leggings and that many flies would hover in front of the lime without alighting and then would alight

just above or just below the danger zone, suggesting that the shiny wet appearance of the lime had a deterrent effect, particularly when the background was light in colour.

Any powder, such as wood ashes, dusted on the lime, reduced the shiny effect temporarily, and more flies alighted, but the efficiency of the lime was also reduced, and most of these flies escaped.

(*c*) *Possibility of the Fly becoming established in the Bush.*

In order to ascertain this point, marked flies (49 males and 11 females) were liberated at the end of the rains at a place about half a mile from the jebel in fairly open bush (Pl. xv, fig. 5), where they were allowed to feed on two Nuba pigs, after which they entered the cover of a thickly overgrown tree, the pigs being driven away as soon as all the flies had disappeared. The flies were always liberated in the morning, and in the evening the pigs were again brought, when one or more flies usually came out from the overgrown tree. Liberations having been made from 6th to 10th October, up to four marked flies (males) were seen daily until 20th October within a few hundred yards of the liberating point. They seemed quite at home and seldom remained on humans for any length of time, probably obtaining food from Nuba cattle, which were found to be visiting the area. No females were seen after being liberated. Thus male flies remained in the bush for ten to fifteen days, and three marked males were recaptured at the edge of the jebel on the following dates, 15th, 25th and 27th October, whither they had probably returned on the cattle.

In October the foliage of all the bush was thick, but there are many parts of it thicker than the experimental area, so that at least during and just after the rains, before the leaf-fall, the fly could almost certainly live and breed there, given a food supply always at hand and a ready means of access from its present haunts. The method of marking was to sever the meso-thoracic tibia half way up ; the left of males, the right of females.

11. Summary.

The paper is an accouunt of a year's work on the bionomics of *Glossina morsitans* in the Koalib Hills, Nuba Mountains Province, Sudan, a small area which lies 200 to 300 miles north of any other locality where *G. morsitans* occurs.

The fly is restricted at all times of the year to the hills, where it was found to breed in rock-shade, and is always closely associated with the Nuba inhabitants and their animals, even frequenting villages and their environs. The cattle, goats and sheep are resistant to trypanosomiasis, but all have been proved to be carriers of the disease.

Wild fauna is scarce in and near the area, and the fly is probably entirely dependent for food on the Nubas and their animals.

An experiment in direct control in a small group of hills is described. It was found impossible to reduce the fly beyond a very low minimum, but the method would be of use as a routine control in small hills.

Experiment with fly lime indicated that the shiny appearance of the lime deterred the majority of flies from alighting upon it.

Marked flies remained in the bush for ten to fifteen days during the rains, but eventually returned to the hills. Given a constant food supply there seems no reason why many parts of the bush, otherwise suitable, should not harbour fly during the rains and early dry season.

The author is indebted to Major R. G. Archibald, C.M.G., D.S.O., M.D., Director of Wellcome Tropical Research Laboratories, and to Mr. H. H. King, Government Entomologist, for much assistance and advice, also to the Provincial and District Officials for help in many ways.

Pig; non-resistant.

Full-grown bull; resistant.

Sheep; resistant.

Two Nuba goats, one half-bred Nuba-Arab; resistant.

Goat and Sheep; resistant.

Ram; resistant.

Types of Domestic Stock in the Nuba Hills.

Explanation of Plate XV.

Fig. 1. Typical scene in fly area ; foot of hills near a village.
Fig. 2. Pile of boulders at foot of a hill, forming a recess in which nine puparia of *Glossina morsitans* were found,
Fig. 3. Nuba village at foot of hills in fly area.
Fig. 4. Chief of Koalib Nubas resting under a rock frequented by *G. morsitans*.
Fig. 5. General view of bush where flies was liberated.
Fig. 6. View of cleared area near a village.

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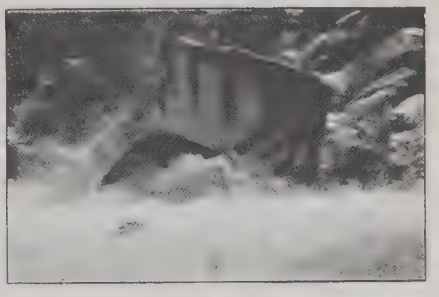

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Tsetse Haunts in the Nuba Hills.

FURTHER BIOLOGICAL NOTES ON *RHYSSA* AND *IBALIA*, PARASITISING *SIREX CYANEUS*, FABR.

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1. Introduction.

The biology of *Rhyssa persuasoria*, L., and of *Ibalia leucospoides*, Hochenw., has already been sketched in a preliminary paper published in this Bulletin (xix, pp. 67–77, pl. iii, 1928) in collaboration with Mr. R. N. Chrystal, of the Imperial Forestry Institute. The following observations were made by the writer chiefly at the Farnham House Laboratory, during the spring and summer of 1928, and are gathered together in view of his departure from England. The work of collecting and rearing supplies of *Rhyssa* and *Ibalia* for shipment to New Zealand, for the biological control of *Sirex noctilio* (*juvencus*), has been continued on a larger scale. The present notes were made incidentally during this work and are arranged under nearly the same headings as in the previous paper, to which they are supplementary. One error needs correcting. It was stated (on p. 75) that the larch (*Larix europaea*, D.C.) is indigenous, though actually planted in the Oxford locality mentioned. As a matter of fact, of course, larch, though Palaearctic, is not indigenous to Britain.

2. Rhyssa persuasoria, L.

In his monograph on the parasitic Hymenoptera, Stellwaag* copies a figure from Hess & Doflein of *Rhyssa persuasoria* ovipositing *in* a *Sirex* larva, buried deeply in wood. The piece of wood is shown in section and the ovipositor is visible throughout its length. The position of the *Rhyssa* is markedly unnatural, and although the figure appears to have been reproduced from a photograph, it is obviously a fake. Moreover, as Mr. Chrystal will show in a later paper, it has now been definitely proved that *Rhyssa* lays its egg *on*, and not *in*, the host larva.

Mating.

Gade,† Champlain‡ and Barlow§ have recorded curious mating phenomena in North American species of *Megarhyssa*. Gade found a great congregation of males of the North American *Megarhyssa lunator* round a tree-trunk. On scraping away the bark he found a female ready to emerge. The males returned and copulation took place at once, but was of very short duration. Champlain states that males of *Megarhyssa atrata*, Fabr., also assemble at points where the female are about to break their way out. Thus early in May in Pennsylvania he found several groups of six to ten males. In every group one of the males had its whole abdomen inserted into the dead tree, through a hole gnawed either by the enclosed female or by the entering male. The hole was only large enough to admit the abdomen of one male, but the others crowded round and tried to force in theirs also. When the tree was split it was found that the male whose abdomen occupied the hole was actually *in copula* with the female.

A careful watch was kept this spring and summer for any similar behaviour in the case of *Rhyssa*, but no indication was found. Moreover, the following experiment seemed to show that females about to emerge have no particular attraction for males. A male which emerged from a gelatin capsule in sawdust on 24th February was placed in a

* Monogr. angew. Ent., No. 6, Beiheft 2, Zeits. angew. Ent. vii : 100 pp. 37 figs. 1921
† Bull. Brooklyn Ent. Soc., vii, pp. 103–104, 1884.
‡ Ent. News, Philadelphia, xxxii, p. 241, 1921.
§ Ent. News, xxxii, p. 291, 1921.

large cage in a warm room, with plenty of food in the shape of raisins and a feeding-tube of honey-water, both of which are readily eaten by both sexes of *Rhyssa*. On the 29th, this male was actually noticed feeding. On the 7th March I introduced three small, open boxes of sawdust. One contained sawdust only, as a control, the others a number of perforated gelatin capsules containing females just about to emerge. During the succeeding $2\frac{3}{4}$ hours the male flew about, fed occasionally, but showed no interest in any of the boxes. The capsules containing the females were barely covered by sawdust.

Mating took place readily in a large cage, which was later kept in the insect-room, illuminated by a Vita-glass lamp. A large female was liberated on emergence at 12·25 p.m. (12th March) in this cage with the above-mentioned male. She could not at first fly, though quite hard, but she began at once to climb upward and with some assistance arrived at the top of the cage at 12·30. There she cleaned herself, first rather perfunctorily her head and face with the first pair of legs, and later with much attention for three-quarters of an hour, the ovipositor and end of abdomen. The ovipositor was repeatedly drawn between the crossed apices of the posterior tibiae, with an upward strain of the abdomen and stretching of the dorsal intersegmental membranes, much as in the actual process of oviposition. When the sheath was separated it was always replaced by the hind pair of legs.

The male meanwhile took no notice at all until 1 p.m., when he was seen on the glass roof, six inches away, walking straight towards the female, with his antennae vibrating. An inch from her he stopped. The female gave no sign of noticing him, but continued to draw her ovipositor between her legs. The male veered and walked past, but returned again and just avoided her. This circling manoeuvre was performed several times, in the intervals of flying occasionally to other parts of the cage. Still the female took no apparent notice. They were watched thus till 1.35, when the female was cleaning her wings and legs, with occasional rests.

On the 14th March at 1.0 p.m. the male was seen flying about, but at 1.5 the pair were copulating. Unfortunately the preliminaries, which must have been short, were missed. The female was clinging to a horizontal bar in the top of the cage with her abdomen hanging limply. The male was clasping her abdomen with his first pair of legs, while his third pair were free and stretched out laterally, the female's wings being pinned to her sides. One middle leg was hooked in the crook of one of the female's hind-legs, or occasionally free. His head and thorax were closely appressed to the side of the female's abdomen, while his abdomen was curved round and forward in a perfect U, to the genital opening at the base of the ovipositor. The antennae of the male were sticking upward and outward, rigid, immobile or slightly vibrating. At 1.10 the female was kicking occasionally and scraping at the male rather violently with her third pair of legs, as though to dislodge him, but he clung like a leech. At 1.15 she had flung him free, though he wrestled violently on her back and curved his abdomen round to copulate again. She very violently squirmed her abdomen and curved it up as though to avoid his. He was thrown off and fell to the ground. At 1.25 he began to crawl up towards the female again. As he approached, the antennae of both vibrated extremely rapidly but with small amplitude —about the same in male and female. Their antennae nearly touched. The female hung in the same position, swinging her ovipositor slightly up and down. The male diverged and walked away at 1.30, his antennae no longer vibrating as he turned, but waving normally. The female's antennae, directed towards him, continued several minutes to vibrate, as at first. Three minutes later there was another tentative approach, but the male veered off again when their antennae almost touched. Again at 1.36 the same thing happened. At 2.5 the female still hung in the same place and position, nearly motionless save for a slight jerking of the ovipositor ; her abdomen not quite so pendant as when mating.

Another female copulated with this same male (26th March) soon after emergence and only half an hour after liberation in his cage, before she had fed. It took place

essentially as described above, but the male clung with all three pairs of legs and thus clasped the females' wings still more closely to her sides. The pair were quiescent for four minutes, save for a rhythmical slow swaying up and down of the tip of the female abdomen. Then the female began to struggle violently and, disengaging her wings, attempted to fly, but fell to the ground with the otherwise dislodged male clinging to a rag of pupal exuviae which still adhered to her ovipositor.

This female was a large specimen, and very active, dashing all over the cage. About 20 minutes after copulation she exuded from the abdomen a drop of clear liquid on the glass.

Observations on a number of additional females confirmed the notion that there is a definite pre-copulatory position, in which the female clings to the horizontal roof of the cage, with the wings somewhat spread and depressed and the abdomen hanging limply and almost vertically, still or waving gently. A very small female, which apparently never succeeded in mating, adopted this position for long periods right up to a few days of her death. The case of this undersized female is extremely interesting. All the females with which copulation occurred were large, fine individuals, and we have seen that one at least was mated within about half an hour of liberation. The small one, on the second day after liberation, approached the male on the gauze side of the cage. Both were vibrating the antennae quickly and shortly, as when about to mate. When near the male she veered round, writhing her abdomen in a curious manner. This manoeuvre was repeated once. The next day she approached the male as before, but when close to him, instead of veering, she flew suddenly on his back. He struggled momentarily as though to throw her off, and she flew away only, however, to draw near again with intensely vibrating antennae. Again she sprang or flew—so quickly, I could scarcely see how – on to his back, and was again thrown off at once. I believe she was never mated, for whereas the other females, after pairing but usually not before, examined with minute attention logs containing *Sirex* larvae, she scarcely visited them once, but spent long periods in what I consider the pre-pairing position.

Copulation with the large females sometimes occurred more than once, and periods spent in the pre-pairing position alternated with intervals of searching and boring in logs. I have, however, no evidence of polyandry. The males, of course, are polygynous.

Though no females kept indoors in the early spring betrayed any interest in logs until after pairing, several virgin females, which were liberated in a still larger cage outdoors in the summer, oviposited freely in larch logs containing *Sirex* and *Ibalia* and produced offspring, the sex of which is not yet ascertainable.

Oviposition.

The process of oviposition in *Rhyssa* resembles less that in *Ephialtes* than we were led to suppose (*l.c.*, p. 69) by Dingler's figures. In a species ovipositing in larch, the whole instrument with its sheath is brought down and directed to the desired spot in the same way as in *Rhyssa*, but the tip of the sheath guides the terebra only momentarily and is then flicked entirely away, to take up its usual caudal (and thus nearly skyward) position even before penetration has actually begun. The thin hair-like terebra, buckling and bending thus performs all the boring unsupported save by the coxae—an extraordinary feat.

In *Rhyssa* there is a certain amount of individual variation. Thus one female was observed in the usual oviposition posture, inserting its instrument into a crack, but instead of passing *between* the hind coxae, it was outside them and to the right of the right leg. This specimen, perhaps through cramping in the gelatin capsule from which she emerged, had her ovipositor bent slightly but permanently to the right, which probably explains this divergence and incidentally throws light on the great

difficulty *Rhyssa* seems to experience in managing her ovipositor. This boring was only a tentative one, lasting a minute or two. Sometimes the ovipositor is slewed round to the point of application with the help of all the legs (more or less in succession) of one side.

Unremitting attempts were made throughout the spring and early summer to see the actual deposited egg of *Rhyssa* in the cages at Farnham Royal, but entirely without success. The few cases in which eggs were laid in large logs were not discovered till after hatching. Mr. Chrystal and his assistant finally succeeded at Oxford, using logs abundantly supplied with large larvae of *Sirex gigas*.

At Farnham Royal, thinking that the logs might contain insufficient material, I had holes bored a few inches apart in small logs and pieces of wood, inserted *Sirex* larvae and corked them tightly. In many cases the *Sirex* larvae continued to feed and remained healthy for many weeks. These artificially infested logs were kept in the cages for months at a time, and the larvae examined at intervals, but with no result. *Rhyssa* females spent long hours examining these pieces of wood, and were often seen boring, even to the hilt of the ovipositor, at points close to the buried larvae. In one particularly striking instance, a fairly thin split piece of wood was used, the holes being bored in its edge, where corks indicated their positions. Thus on the face of the piece there was nothing to show where the larvae lay. A female was observed walking along the face, tapping in the usual way with her antennae. She stopped and bored, not deeply, exactly over the site (as indicated to me, in side view, by the cork) of a larva. She crawled along further and lingered over another buried grub, curving the antennae more abruptly at the tip and tapping more meticulously. In neither case was an egg laid, but this behaviour, coupled with that of the other females found boring exactly where larvae were buried, renders it clear that olfaction or audition (or both) are involved in the process of immediately locating the host.

A *Sirex* larva inserted in a shallow crevice, which exposed part of it to view, was visited several times by different females, one of which actually touched it first with her antennae and then with her probing ovipositor, but no egg was laid.

Dr. Thompson then suggested a technique which had been eminently successful, even with strange and unaccustomed hosts, in the case of *Pimpla* (*Exeristes*) *roborator*, Fabr., parasite of the corn-borer (*Pyrausta nubilalis*). The host larva was enclosed in a corn-pith cell, strongly perforated and smeared with the body fluids of the host larva. As no pith was available, two cells were made, one of polyporus and the other of peat slabs, both perforated so that the larva was almost visible. The outside was smeared copiously with the body contents of another *Sirex* larva. *Rhyssa* females, even when actually placed on these baits, betrayed but a languid interest, and no oviposition took place. The enclosed *Sirex* larvae even pupated and one eventually emerged. This experiment succeeded no better in a large insectary, where the insects flew freely, than in the cage.

In the field, the proportion of *Rhyssa* oviposition borings which yielded, not only no eggs, but often no sign at all of the host, was as great as in the preceding season. This, coupled with the behaviour above described, makes it evident that by far the greatest and " intrinsic limiting factor " (to adopt Thompson's term) to the increase of *Rhyssa* is its own innate inefficiency. Both in the field and in captivity it would seem that, at a generous estimate, three-quarters of its time is spent in fruitless boring, often where no host exists within a considerable radius. In parasitic Hymenoptera in general, as Dr. Thompson has suggested, there is probably very much more random thrusting with the ovipositor than is usually realised, but in those which, like *Rhyssa*, bore in solid wood, the apparently wasted effort is necessarily far more conspicuous, and the time lost considerably greater.

In one of the captive females, mated in the cage as described above, an egg was found on 12th March, entangled between the terebra and sheath of the ovipositor.

The insect itself eventually disengaged it by drawing the instrument between the crossed tips of her hind tibiae. This egg, which was recovered uninjured, agreed well with Bugnion's description. It was 13 millimetres long, of which the pedicel made up 10.

It appears that *Rhyssa* sometimes oviposits on pupae of the host. Thus on 10th July a first-stage larvae of *Rhyssa* was found on a newly formed *Sirex* pupa, which bore a number of blackish spots—one on the left hind wing-pad, three on the side of the abdomen near its tip, one on the base of the venter, one at the base of the right antenna, one just in front of right fore-wing pad—thus seven in all. The spots looked very like the seats of punctures, and it is difficult to suggest what else they could be. Moreover I could detect no signs of heart-beat, though this latter is less significant from the fact that the heart-beat is in any case difficult to see in a *Sirex* pupa. In a full-grown *Sirex* larva, however, which had been recently oviposited upon in one of Mr. Chrystal's cages, no heart-beat was discernible even under the highest magnification of a binocular, though a normal but similar larva showed a heart-beat of 24 per minute. This parasitised larva was kept in a gelatin capsule, packed in sawdust, in company with a number of normal ones, similarly encapsuled, which carried on their development. On 25th August, or rather more than two months after parasitisation, it was apparently unchanged, nor was any heart-beat perceptible. On 8th October the head and thorax had turned brownish, but the rest seemed normal and in excellent condition.

Evidently, then, *Rhyssa* stings the host larva before ovipositing upon it, and either kills it or paralyses it so thoroughly that even the action of the heart is stopped. I have shown elsewhere that the Braconid, *Alysia manducator*, when ovipositing in *Calliphora* larvae, stops their heart-beat for a period varying from some seconds to a quarter of an hour. If *Rhyssa* kills the *Sirex* larva it is difficult to understand how decay is so long delayed, for dead and injured larvae kept in similar capsules in sawdust have been found to discolour in a few days, and eventually they either dry up, or change into a deliquescent brown mass. If the number of punctures in the larva studied is at all typical, the stinging must be a very thorough process.

Thus Bordas (1917), who was astray in his supposition that the *Rhyssa* egg is deposited in the host larva, was perhaps not far from the truth when he suggested that the liquid from the " glandes venimeuses," " injected into the larva of the *Sirex* when the egg is laid, must be endowed with anaesthetic properties and also preserve from decay the larval tissues."

Movement and Resting Position.

In the Farnham Royal insectaries the gauze sides are fastened to the teak framework by smooth strips of sheet copper about an inch wide, one of which extends right round just at the top of the walls. It was curious that *Sirex cyaneus* and *S. gigas*, crawling up the gauze sides, were invariably baffled by this strip, and never learned to cross it, but would cling to the gauze for hours on end, pawing hopelessly at it with their front feet. *Rhyssa*, however, learned to negotiate it in a very short time, varying somewhat with the individual. For instance, a female that emerged on 12th March was liberated in a large cage, lined on the floor and for nearly an inch up the sides with zinc. She immediately ran jerkily and quickly across the floor and essayed in vain to climb up the side. I finally supplied her a blotting-paper ladder, by which she rapidly climbed to the gauze and up it to the top wood-work, where, however, the glass roof again baffled all her efforts. Yet the male, which had been liberated some weeks before was walking about with ease, upside down, across this glass roof. By the 20th this female was able to do the same with equal facility. This implies a considerable power, both of learning, and of adaptation to conditions not experienced in the natural environment.

The resting (and probably sleeping) position of *Rhyssa*, adopted in dull and cold weather or towards evening, is quite unlike the female's pre-pairing posture. The head and body are in one straight line, inclined at an angle of 30° to the surface—usually the wood-work of the cage-roof—on which the insect rests. The wings are folded, the antennae stretched in front, along the plane of the resting surface, and diverging from each other at an angle of about 45°. The first pair of legs are held close to the body, the others extended nearly parallel to one another and about at right angles to the body.

3. **Ibalia leucospoides,** Hochenw.

All stages of *Ibalia* larvae have now been found, and are being studied morphologically by Mr. Chrystal. The intermediate instars show a conspicuous tail like that of an Ichneumonid larva, and a body with distinct segmentation.

Larch logs cut at Oxford in the autuun, and sent to Farnham Royal by Mr. Chrystal, were cut up at intervals during the winter and early spring. These trees were quite green and were barely dying at the time they were cut. When the bark was removed every *Sirex* oviposition-bore was at once obvious, surrounded by patches of brown, discoloured tissue. Since, as indicated in the previous paper, the female *Ibalia* oviposits only in the egg tunnels of the host, the task of finding all the *Ibalia* material was simple.

It is proposed here only to give a few figures as an indication of the extent of parasitism, and to leave the intimate details of the structure and biology of the larvae to Mr. Chrystal's paper.

On 17th January, nineteen *Sirex cyaneus* egg tunnels were dissected out of a log which was still green and sappy. These yielded 13 young *Sirex* larvae, two of the tunnels containing two larvae each, and the remainder being empty or filled only with secretion. Only one larva, the further-in member of a pair, was parasitised, and this contained two relatively large *Ibalia* larvae. From 16th to 19th March no fewer than 64 *Sirex* egg-bores were dissected out of a two-foot larch log. Some of these were short, did not contain even secretion, and were evidently trial bores. There were three *Sirex* eggs, two in one tunnel and one in another, all unduly soft and probably addled, which would account for their non-hatching at such an advanced date ; 38 young larvae were found, ten of the tunnels containing two larvae, and one three ; 36 tunnels, including the trial-bores mentioned above, were empty or contained only secretion ; 8 of the larvae were dead, shrivelled and dried-up, possibly owing to some cause proceeding from the cutting and partial drying of the log. One larva in a tunnel by itself contained a first stage *Ibalia* larva, while another, in a burrow with a fellow, had an *Ibalia* egg. Adding together the results of these two examinations the parasitism by *Ibalia* was at the rate of 5·9 per cent.

With regard to the burrowing behaviour of parasitised larvae, a case was observed on 3rd April in which the host had followed an exceedingly winding course and when found was just completing a flat spiral, which brought it back just below an earlier part of its burrow. This was entirely within the superficial part of the trunk, in marked contrast to the course of a normal larva of the same age.

4. Inter-Relations of Rhyssa and Ibalia.

In the previous paper it was stated that the risk of superparasitism of *Rhyssa* upon *Ibalia* is probably absent. The possibility of direct hyperparasitism was not envisaged. Nevertheless a case has come to light in an outdoor cage containing virgin females of *Rhyssa* and larch logs infested with *Sirex cyaneus* and some *Ibalia*. On 16th July a *Rhyssa* larva 8·5 mm. long was found on a white *Ibalia* pupa. By the 21st merely the skin of the host remained.

Such hyperparasitism is perhaps not of frequent occurrence, but the larva or pupa of *Ibalia*, by virtue of the changed course of the parasitised host, is never out of reach of the ovipositor of even a small *Rhyssa*.

5. Technique.

The gelatin capsules packed in sawdust have continued to prove satisfactory for larvae and pupae which have finished feeding. The atmosphere in large containers may be kept sufficiently moist, without softening the capsules, if a reagent bottle be buried up to its neck in the sawdust, and supplied with a short wick of cotton-wool. *Ibalia* as well as *Rhyssa* has now shown its ability to cut its way out of the capsules when ready to emerge. Some individuals, especially undersized ones, do however occasionally fail. At Dr. Thompson's suggestion the task has been simplified by denting slightly the head-end of the capsule with the thumb-nail.

COLLECTIONS RECEIVED.

The following collections were received by the Imperial Bureau of Entomology between 1st July and 30th September, 1928, and the thanks of the Managing Committee are tendered to the contributors for their kind assistance :—

Dr. W. M. Aders :—26 Formicidae ; from Zanzibar.

Mr. A. Audant :—3 Diptera, 17 Coleoptera, 5 Hymenoptera, and 6 Rhynchota ; from Haiti.

Capt. P. J. Barraud : –8 Siphonaptera, 25 Diptera, and 3 Rhynchota ; from Tibet.

Mr. G. E. Bodkin, Government Entomologist :—14 Hippoboscidae, 2 Anoplura, and 1,783 Ticks ; from Palestine.

Dr. G. Bondar :—145 Coleoptera and 7 early stages and 8 Lepidoptera ; from Brazil.

Chief Entomologist, Pretoria :—94 Coleoptera and 12 Rhynchota ; from South Africa.

Mr. E. C. Chubb, Durban Museum :—106 Rhynchota ; from Natal.

Mr. L. D. Cleare, Junr., Government Entomologist :—6 Diptera, 3 Coleoptera, 1,000 Chalcididae, and 62 Rhynchota ; from British Guiana.

Prof. T. D. A. Cockerell :—15 Culicidae, 97 other Diptera, 226 Coleoptera, 21 Parasitic Hymenoptera, 6 other Hymenoptera, 31 Lepidoptera, 3 species of Coccidae, 189 other Rhynchota, 32 Orthoptera, 10 Ephemeridae, 2 Chrysopidae, and 10 Odonata ; from Asia and Australasia.

Mr. G. H. Corbett, Government Entomologist :—106 Diptera, 89 Coleoptera, 81 Parasitic Hymenoptera, 15 Formicidae, 137 Lepidoptera, 41 Rhynchota, and 5 Orthoptera ; from the Federated Malay States.

Mr. G. S. Cotterell, Assistant Entomologist :—20 Parasitic Hymenoptera ; from the Gold Coast.

Mr. H. S. Cunningham, Plant Pathologist :—2 Lepidopterous larvae ; from Bermuda.

Mr. A. Cuthbertson :—44 Rhynchota ; from Southern Rhodesia.

Mr. L. Daviault :—12 Parasitic Hymenoptera ; from France.

Director of Agriculture and Forests, Palestine :— 7 Rhynchota ; from Palestine.

Director of Agriculture, Gambia :—60 Coleoptera ; from the Gambia.

Dr. H. S. Evans :—293 Coleoptera, 4 Formicidae, 3 Isoptera, 2 Rhynchota, and 2 Orthoptera ; from Northern Rhodesia.

Mr. T. Bainbrigge Fletcher, Imperial Entomologist :—92 packets of Coccidae, 8 other Rhynchota, and 157 Orthoptera ; from India.

Mr. C. Franssen : —6 Rhynchota ; from Java.

Dr. C. Fuller :— 95 Coleoptera ; from Portuguese East Africa.

Mr. J. C. M. Gardner, Systematic Entomologist :—24 Curculionidae, 33 Parasitic Hymenoptera, 8 Lepidoptera, and 37 Psyllid nymphs ; from the United Provinces, India.

Dr. L. Gill :—21 Braconidae ; from South Africa.

Mr. P. v. d. Goot :—19 Coleoptera and 100 Rhynchota ; from Java.

Mr. W. Greenwood :—28 Lepidoptera ; from the Fiji Islands.

Mr. G. L. R. Hancock, Assistant Entomologist :—2 Hippoboscidae, 4 Psychodidae, 7 Coleoptera, 99 Parasitic Hymenoptera, 42 Lepidoptera, and 2 Ephemeridae ; from Uganda.

Mr. E. Hargreaves, Government Entomologist :—8 Culicidae, 66 other Diptera and 2 pupa-cases, 623 Coleoptera and 2 early stages, 340 Parasitic Hymenoptera, 140 other Hymenoptera, 88 Lepidoptera, 19 Isoptera, 18 Thysanoptera, 11 species of Coccidae, 5 species of Aphidae, 296 other Rhynchota, 55 Orthoptera, 4 Planipennia, 3 Odonata, 2 Trichoptera, 30 Mites, 2 Centipedes, and 6 Millipede cells ; from Sierra Leone.

Mr. G. F. Hill, Entomologist :—12 Collembola ; from Victoria, Australia.

Indian Museum, Calcutta :—6 Curculionidae and their cocoons ; from Iraq.

Dr. A. Ingram :—26 Culicidae and 7 slides of Culicid preparations ; from South Africa.

Mr. J. L. Khare : 103 Orthoptera ; from India.

Mr. C. B. R. King :—2 Chalcididae and 1 species of Coccidae ; from Nyasaland.

Mr. W. R. S. Ladell :—4 Culicidae, 53 Tabanidae, 166 other Diptera, 592 Coleoptera and 9 larvae, 40 Parasitic Hymenoptera, 270 other Hymenoptera, 1,260 Lepidoptera, 3 species of Aphidae, 273 other Rhynchota, 581 Orthoptera, 6 Planipennia, 13 Trichoptera, a number of Mites, and 2 Spiders; from Siam.

Dr. Ll. Lloyd :—9 Coleoptera, 232 Orthoptera, and 7 Odonata ; from Northern Nigeria.

Mr. J. W. McHardy :—1 Phasmid ; from Tanganyika Territory.

Dr. C. Manalang :—6 Culicidae ; from the Philippine Islands.

Dr. R. Menzel :—34 Parasitic Hymenoptera and 2 Formicidae ; from Java.

Mr. L. D. Moritz :—116 Orthoptera ; from Transcaspia.

Mr. C. F. W. Muesebeck :—30 Braconidae ; from Hungary.

Nairobi Museum :—15 Diptera, 109 Coleoptera, 2 Chalcididae, 97 other Hymenoptera, and 2 Spiders ; from Kenya Colony.

Mr. R. J. Nel :—6 Tabanidae, 264 other Diptera, 388 Parasitic Hymenoptera, and 556 other Hymenoptera ; from South Africa.

Mr. A. S. Nicolay :—49 Curculionidae ; from Africa and the Canary Islands.

Prof. G. H. F. Nuttall, F.R.S. :—5 Hippoboscidae ; from Italy : and 1 species of Coccidae ; from the Balearic Islands.

Mr. A. W. J. Pomeroy, Government Entomologist :—11 *Glossina*, 8 puparia, and 3 slides of genitalia ; from the Gold Coast.

Mr. Y. Ramachandra Rao, Government Entomologist :—4 Diptera, 19 Coleoptera and 30 larvae, and 22 Parasitic Hymenoptera ; from South India.

Mr. A. Reyne :—40 Coleoptera and 8 early stages ; from the Dutch East Indies.

Dr. Helen Russell :—16 Culicidae ; from the Gold Coast.

Dr. Hugh Scott, Government Entomologist :—12 Tabanidae, 105 Coleoptera and 9 larvae, 2 Lepidoptera, 19 Rhynchota, 57 Orthoptera, and 2 Odonata ; from Kurdistan and Iraq.

Mr. D. G. Sevastopulo :—74 Orthoptera ; from Cawnpore, India.

Mr. H. W. Simmonds, Government Entomologist :—13 Diptera, 6 Coleoptera, 15 Chalcididae, 2 species of Coccidae, 5 other Rhynchota, and 2 Orthoptera ; from the Fiji and Solomon Islands.

Mr. E. R. Speyer :—35 Parasitic Hymenoptera ; from England.

Mr. M. Sureya :—4 Diptera, 2 Parasitic Hymenoptera, and 15 Orthoptera ; from Asia Minor.

Wellcome Tropical Research Laboratories, Khartoum :—22 Orthoptera ; from the Sudan.

Mr. G. N. Wolcott :—6 Curculionidae ; from Peru.

Dr. F. Zacher :—3 Coleoptera ; from Brazil.

Zoological Museum, Berlin :—247 Parasitic Hymenoptera ; from various localities.

A CONTRIBUTION TO THE LIFE HISTORY OF THE LAC INSECT, *LACCIFER (TACHARDIA) LACCA* (COCCIDAE).

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(Plate XVI.)

The author desires to express his sincerest thanks to the authorities of the Zoological and Geological Survey of India and of the Asiatic Society of Bengal for allowing him to consult the necessary literature in their respective libraries, and to the members of the Lac Association Committee and Mrs. D. Norris, the Director of the Institute, for their generous help. He is also much indebted to Mr. W. B. R. Laidlaw, the Entomologist, for going through the manuscript, and to the artist, Mr. E. Heber, for the illustrations accompanying the paper.

Sex Identification in newly hatched Larvae.

Carter was the first worker to attempt sex identification shortly before sexual maturity. After him, Roxburgh was the first to mention a female crawling larva as being distinct from the male ; but as he confessed that he did not know the male and as this cannot be called comparison, his claim to early recognition of the female sex can hardly be accepted, especially as he wrongly identified the sexes even in the adult stage. Carter casually refers to the absence of dimorphism of the sexes in the earliest stage of the lac insect by saying, " All are alike, apparently, when first attached." McKee, who cites Carter as the source of his information on the biology of the lac insect, says that the male and female larvae are identical in size and shape. G. Watt says, " At this stage it is impossible to distinguish sexes." Lowrie says, " At this stage the distinction between the male and female cannot be traced." Stebbing also mentions that " It is impossible to observe any distinction of sex at this stage of life." Misra says, " At this time there is very little difference between the male and female insect." Imms & Chatterjee state " In the newly hatched larva the sexes are indistinguishable by any external characters and it is not until after metamorphosis has set in that the separation into sexes becomes evident." Last comes Mahdihassan, who says, " We have examined a large number of the newly hatched larvae of *Tachardia lacca* (*Lakshadia indica*) and other Coccids and have been unable at this stage to find any external manifestation of the sexes."

Consequently attempts were made to determine the sex of the larvae by using the following external characters :—

	Male larva (fig. 1).	*Female larva* (fig. 2).
1. Shape	The dorsal surface of the body flat ; the posterior end of the body abruptly narrowed.	The dorsal surface of the body raised medially ; the body narrows gradually towards the posterior end.
2. Anal tubercle ...	More or less straight.	Slightly raised.
3. Colour	Appears more pinkish or crimson, due to thin coating of wax.	Slightly darker pink or crimson, due to thicker coating of wax.

Experiments to test these characters were then carried out during three seasons. Each time two separate plants were taken, one for the supposed male larvae and the other for the supposed females. The plants were in a place where there was no chance of infestation, even by wind, and the numbers of larvae either living or dead were noted at regular intervals.

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Altogether, in four experiments, 1,149 supposed male larvae were placed on the trees ; of these 776 were washed off by rain or blown away and 325 died ; thus only 48 reached maturity or the prepupal stage, and of these 43 were males and only

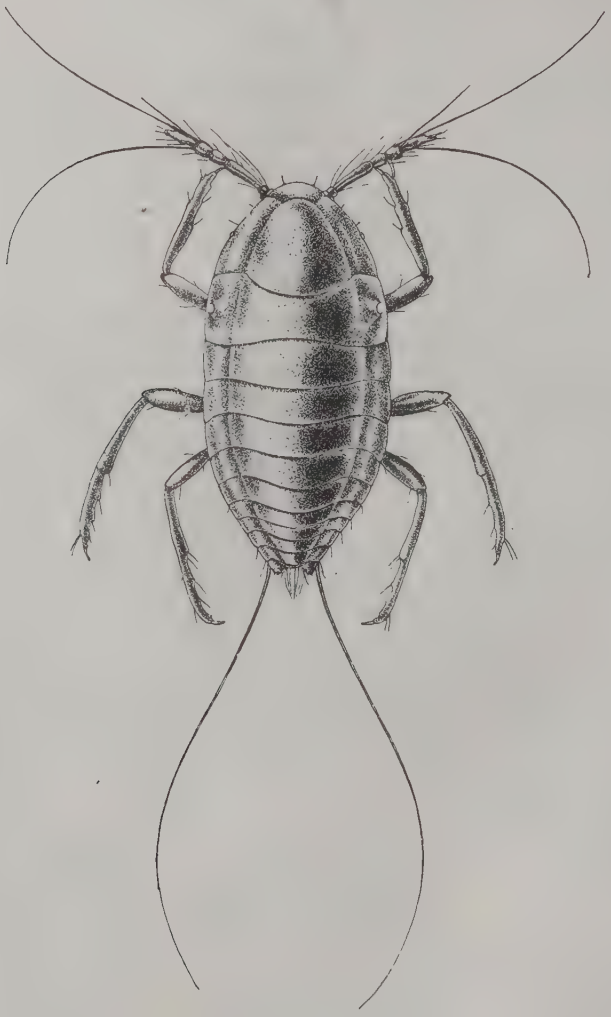


Fig. 1. *Laccifer* (*Tachardia*) *lacca*, Kerr, ♂ larva immediately after emergence ; ×100.

5 females. Similarly, 1,061 supposed female larvae were used ; of these 647 were washed or blown away and 346 died ; of the 68 that reached maturity 63 were females and only 5 males. Thus by utilising the characters given above it proved possible

to identify correctly the sex of 89·6 per cent. of the males and 92·6 per cent. of the females. But this method of sorting the sexes of the young larvae with the binocular microscope is tedious and of little practical value.

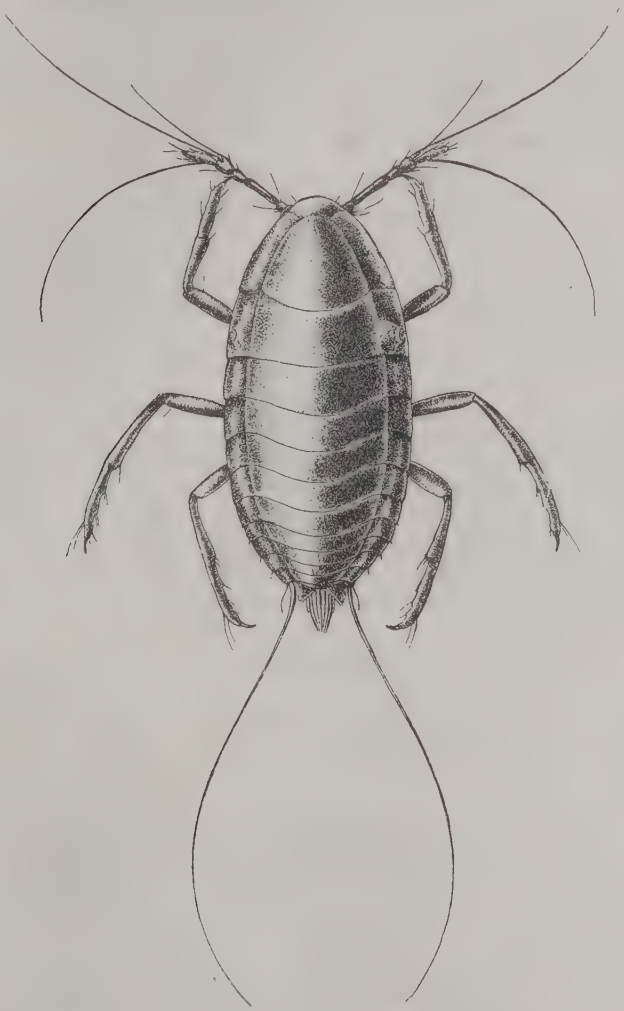


Fig. 2. *L. lacca*, ♀ larva immediately after emergence; ×100.

External Resinous Developments from Larva to Adult.

Mahdihassan is the only worker who has systematically studied the resinous developments in the first few larval stages. This he undertook to find the sex-ratio prior to maturity, having failed to distinguish at first a newly emerged male larva from a female one. I took up the work independently in July 1926, and was glad to find later that I fully agreed with Mahdihassan's conclusions regarding the stages

which he has so well described in his paper, " Early recognition of sex among the lac insects."

The larva has a dorsal shield of wax on its back, which never disappears but undergoes systematic change in shape in accordance with the growth of the larva and the secretion of resin. The growth of the male larva differs from that of the female from the start. The male larva grows longitudinally, and the female grows vertically to the plane of attachment. The male larva secretes less wax and resin than the female, even in the first and second stages when both are feeding, with the result that the colour of the male tests of the larval, prepupal and pupal stages is always lighter than that of the corresponding female tests.

The larval resinous developments were studied during the kartiki (winter) crop in four broods : (1) Jodhpur yellow Ber lac, on Ber (*Zizyphus jujuba*) ; (2) Palas (*Butea frondosa*) lac, on Ber ; (3) Kusum (*Schleichera trijuga*) lac, on Kusum ; and (4) Ber common crimson lac, on Ber. Weekly observations were taken, and differences noted. Care was taken to figure the intermediate stages only, avoiding the particularly advanced and backward stages in order to get the average development from larval to adult stage. Fundamentally, the growth in all the four broods is the same, but differences occur in the time of moulting of the male and female larvae of the different broods, and in the time of reaching maturity. Accordingly, the external resinous developments in some respects vary in their appearance. The resinous developments week by week in the Jodhpur yellow Ber on Ber brood are described below. The Jodhpur yellow Ber lac insect, which occurs with the crimson variety in a particular locality of the Jodhpur State, secretes a beautiful yellow lac resin, which if it yielded a superior quality of shellac would be much appreciated by manufacturers. It was first brought to the Institute by Mr. N. K. Sarkar, the Crop Statistician, at the request of the late Entomologist, Mr. C. S. Misra. The yellow and red varieties both probably breed true to type. Most of the figures in the plate had to be drawn from material preserved in 4 per cent. formalin, and so only remnants of the white filaments of the brachial plates and the anal tube are seen in the illustrations.

Jodhpur yellow Ber Brood lac on Ber (Pl. xvi, figs. 6–14, 16).

Age.	*Male.*	*Female.*
2 weeks old ...	1. Longer than the female, body dorsally flat, due to the longitudinal growth.	1. Smaller than the male, dorsal surface of the body raised, especially in the median plane, owing to the vertical growth.
	2. The posterior part of the body much narrower than the brachial region, owing to more growth in the thoracic region. Setae on the anal ring porrect.	2. Posterior part of the body not abruptly narrower than the brachial region as in the male. Setae on the anal ring nearly porrect.
	3. Major apical hairs still present, showing that the moulting has not yet taken place, and that the larva is still a *first stage larva.*	3. Major apical hairs present, showing that the larva has not moulted yet and it is still a *first stage larva.*
3 weeks old ...	1. Two depressions appear on the resinous test, one between the 2nd and 3rd segments, and the other between the 7th and 8th segments.	1. Two prominent depressions appear as in the male, and the female test becomes oval, owing to the deposition of resin and wax laterally and posteriorly.

Age.	*Male.*	*Female.*
	2. Apical hairs fall out, and the anal setae appear more bushy, showing that the larva has moulted and become a *second stage larva.*	2. Apical hairs fall out, the anal setae appear more bushy, showing that the larva has moulted and become a *second stage larva.*
	3. The colour of the test is lighter than that of the female, owing to less secretion of wax and resin.	3. The colour of the test darker than that of the male, owing to more secretion of wax and resin.
5 weeks old ...	1. Body of the male attains almost full size, and the male resinous test is slightly arched. This is the *prepupal stage.*	1. No important change occurs.
6 weeks old ...	1. The male test attains its full size, operculum is developed, and whole insect enclosed in the test. This is the *pupal stage.*	1. More resin and wax is deposited round the posterior half of the body, and the test appears practically oval.
8 weeks old ...	1. Males emerge now, by raising the lid of the operculum.	1. Test almost globular, except the marginal fringe with brachial openings situated medio-dorsally. The anal opening on the posterior part of the body.
14 weeks old ...		1. The resinous test almost globular. The anterior half of the body somewhat more attenuated than the posterior half. The brachial openings and anal opening equilaterally situated on the medio-dorsal side of the body.

The third week resinous developments of the Jodhpur yellow Ber × Ber are delayed in the case of Palas × Ber and Kusum × Kusum to the fourth week ; and the sixth week developments of the male tests of the former are delayed to the seventh week in all the latter three brood lacs, including common Ber × Ber. The Kusum lac female test goes on increasing in size after the 14th week also, but there is no material change in shape. Besides the above principal differences, there are minor differences in the general shape, etc., of the male and female tests of the above four broods. It should be remembered that the external resinous developments are strictly related to the metamorphoses in the developing larvae, which seem to depend on the supply of food and climatic conditions, etc. Consequently the third, fifth and sixth week resinous developments may occur in the second, third and fifth weeks, or even earlier or later in the same season, according to the climatic conditions and suitability of the host-plant. I have noticed at Namkum that the development was quicker during the kartiki (winter) crop of 1927 than it was in the year 1926, when the above observations were taken. The males in the kartiki crop of 1927 first began to emerge in the sixth week ; and in the kartiki crop of 1926 the first emergence of males was in the 7th week. At Mathurapur, Malda District, Bengal, which is hotter and damper than Ranchi, the emergence of males in the year 1926 began in the fifth week, that is, just a month after inoculation.

Description of First Stage Larva (figs. 3, 4).

So far as my knowledge goes, no particular attempt has been made hitherto to study, critically and systematically, the morphological developments of any species of TACHARDIINAE from larva to adult. Imms & Chatterjee have described metamorphosis in the male, more completely than in the female, though the description of the former is incorrect in some details. Chamberlin has enumerated and figured some parts and characters of the "first stage larva," and of the "second stage of female," while dealing in general with the subfamily TACHARDIINAE, but has not touched the developmental stages of the male. I therefore propose to describe the developmental changes observed in material obtained from twice-weekly collections of the kartiki (winter) crop in Ber × Ber, and periods of the corresponding stages in the baisakhi (summer) crop will be pointed out.

The newly emerged larvae of the common Ber brood are crimson in colour and elongate oval in shape, tapering from the anterior to the posterior extremity. The posterior end of the male larva is narrower than that of the female, and tapers more sharply from the brachial region. In the female the tapering is gradual from the anterior to the posterior extremity (figs. 1, 2). The larvae measure from 0·575–0·625 mm. in length, excluding antennae and caudal setae; and 0·2–0·25 mm. in the maximum breadth in the brachial region.

Head. The antennae are six-jointed; the first two basal joints small and stout; the third joint the largest, though relatively slender, and slightly curved near its anterior end; the fourth and fifth joints almost equal in length; the sixth a little shorter than the third, and imperfectly divided into a longer stout proximal portion and a smaller and more slender distal portion; nearly all the segments of the antennae bear setae (figs. 1, 2). The eyes are situated on either side of the head behind the antennae and appear as circular dots. Almost all the mouth-parts of the adult female seem to be represented in the larval stage, the maxillae and mandibles being prominent though modified in form. The mandibles are longer and stouter than the maxillae, and the two together form a conspicuous tube, which, when not in use, is withdrawn into a backwardly directed sheath extending along the greater part of the ventral side of the insect.

Thorax. Close to the anterior pair of legs on the prothorax is situated a pair of anterior spiracles. Leading outwards and upwards from each spiracle is a short spiracular groove, at the end of which, on the dorsum, is a small brachial plate. Each brachial plate is perforated by a variable number of pores, and towards its periphery are seen short setae; the number of pores in the brachial plate of the female larva is generally more than in the male, but it is not fixed, and may vary in the two brachial plates of the same individual. The posterior spiracles lie between the bases of the 2nd and 3rd pairs of legs, and slightly outside them. Each leg consists of a two-jointed trochanter, a stout femur, a slender tibia, and a single-jointed tarsus, which terminates in a curved claw.

Abdomen. This has nine apparent segments and the apex bears a pair of elongate slender setae, or apical hairs. The anus is surrounded by a circle of six perforated anal plates, each bearing a prominent seta.

Metamorphosis in the Male (fig. 3).

In the kartiki crop, the male Ber larva after fixation grows in length and breadth during the first two weeks (fig. 3 *a*) and moults for the first time in the third week, thus losing its legs, antennae, and major apical hairs. In the baisakhi (summer) crop the male larva moults for the first time from the 7th–10th week. Imms & Chatterjee are mistaken in saying "Male larvae can be recognised soon after this first moult or ecdysis, by the fact that the three tufts of white filaments remain quite small and undeveloped." These tufts are as well developed in a second stage male as they

are in the second stage female (Pl. xvi, figs. 10, 11). Besides this, there appears no reason why the filaments in the second stage male larva should remain quite small and undeveloped, seeing that its brachial plates are as well developed as those

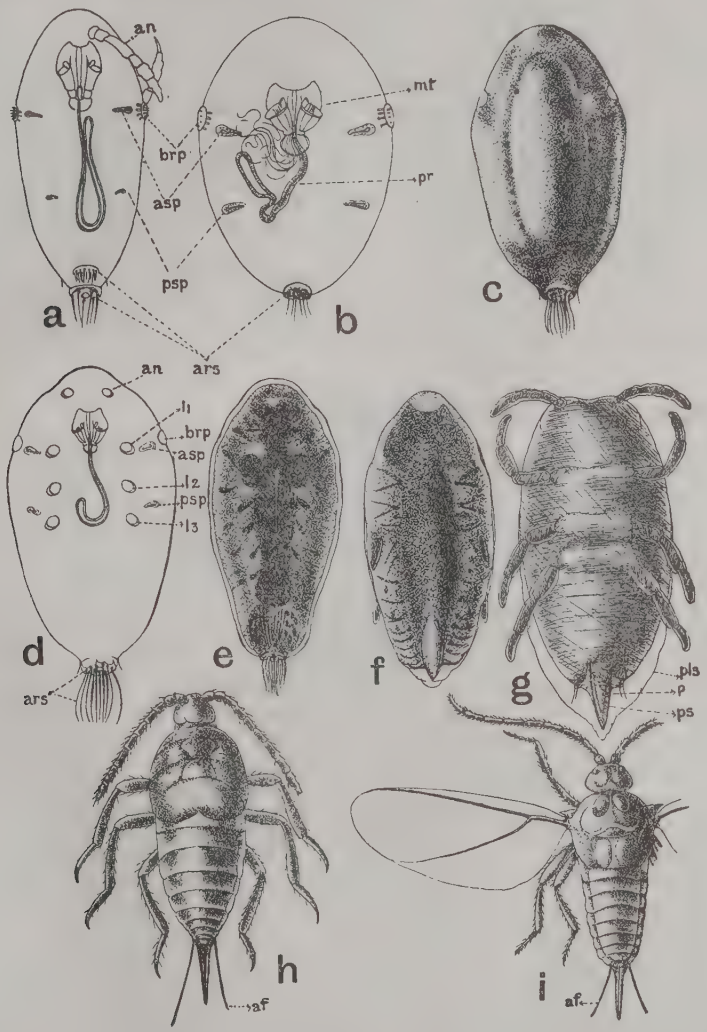


Fig. 3. *L. lacca*, developmental forms of ♂: *a*, larva ready to moult, dorsal view, ×50 (cleared); *b*, newly moulted larva, ventral view, ×35, (cleared); *c*, newly moulted larva, dorsal view, ×50; *d*, prepupal stage, ventral view, ×35, (cleared); *e*, prepupal stage, dorsal view, ×30; *f*, pupal stage, dorsal view, ×30; *g*, pupal stage, ventral view, ×50, (cleared); *h*, apterous adult, dorsal view, ×25; *i*, winged adult, dorsal view, ×20.

of the second stage female, and the number of anal ring setae (*i.e.* 10) is also the same in both. In the second larval stage (*b*, *c*) the larva has well developed brachial plates, with distinct nuclear ducts, unlike those of the first stage larva. The usual

mouth-parts of the larva, developing buds of the legs, and antennae, may be present or absent. The anterior and posterior spiracles, and the six anal ring plates, have ten setae instead of six, the usual number in the first stage larva. It grows in size and measures 0·77–1·125 mm. in length, and about 0·45–0·675 mm. in maximum breadth. In the 4th or 5th week it passes to the prepupal stage (*d*), measuring 1·15–1·425 mm. in length, and about 0·6 mm. in breadth. In this stage the indications of the antennae and legs become apparent. In the baisakhi crop this stage is reached in 12–14 weeks. Ultimately in the 6th or 7th week the full pupal stage is reached. The pupa ceases feeding, but does not stop secreting resin. This is evident from the fact that the operculum of the male test is formed only when the larva has reached the pupal stage. The pupa lies enclosed in the second stage larval skin. It also has a pupal skin proper, which forms a sheath for the free, inert and rigid antennae and legs. At the posterior extremity of the abdomen lies the penis enclosed in the pupal skin. The pupa measures 1·375–1·425 mm. in length, and about 0·625 mm. in maximum breadth. In the pupal stage the only larval organs remaining are the anterior and posterior spiracles. In the baisakhi crop this stage is reached in the 16th to 18th week. On completion of the pupal stage, the insect sheds the second stage larval skin, and ultimately the pupal sheath, to emerge as an adult (*h*, *i*) after 32–50 hours, by raising the opercular lid with the posterior parts of the body.

Metamorphosis in the Female (fig. 4).

The female larva grows more in breadth than length during the first and second week of the kartiki crop after fixation (fig. 4, *a*, *b*) and moults for the first time like the male larva in the third week, while in the baisakhi crop it moults for the first time in the 7th–10th week. A newly moulted larva measures about 0·6 mm. in length and 0·375 mm. in maximum breadth. In the second stage larva (*c*, *d*) the antennae are reduced, the legs are lost altogether, and the number of brachial pores in the brachial plate increases. The brachial plate measures 0·075 mm. in diameter ; the nuclear ducts in them also become prominent and number from 4 to 7. The anterior spiracles measure 0·075 mm. in length and the posterior spiracles 0·0375 mm. The number of setae in the anal ring plates becomes ten instead of six. Two of these plates, which lie mediolaterally, bear one seta each, and the other four bear two setae each, as in the adult female. Derm pores, or marginal and dorsal duct clusters, become prominent in the oral and brachial region. In the 4th and 5th weeks the young second stage female larva measures 0·625–0·675 mm. in length, and 0·5–0·62 mm. in breadth ; the marginal and dorsal duct clusters also become more prominent. In the 6th week it moults, most probably for the last time, in the kartiki crop, and in the 15th and 16th week in the baisakhi crop. According to Mahdihassan the female larva moults thrice, but so far I have been able to observe only two moults. The dorsal spine makes the papilla-like appearance for the first time during this week (*e*, *f*). The moulted larva can be now called a young or virgin female. In the seventh week the dorsal spine is fully formed,but is not chitinised enough to withstand hot KOH. The so-called " pre-oral " lobes also become prominent. I prefer to call them post-oral lobes, because they lie posterior to the mouth in the early stages, when there is not much distortion of the body, and only come to lie anteriorly when complete distortion has taken place. In the 8th week female (*g*) the rudimentary antennae, with three segments, tipped with four large and two small setae, are distinctly visible, the perivaginal pores become prominent, and the dorsal spine, with its glands, becomes chitinised enough to stand hot caustic potash solution. The size of the female at this stage is 1·0–1·525 mm. in length, and 0·75–1·25 mm. in breadth. In the 11th week, the distortion of the parts in the female is fairly advanced, with the result that the brachial plates and the anterior spiracles come to lie posteriorly, and the posterior spiracles anteriorly and a little behind the mouth-parts. In the mouth, the hitherto undescribed and unfigured wax-gland ducts (fig. 6, *a*, *b*)

become prominent, as also do the post-oral lobes. In the 13th week, the anal tubercle becomes almost fully developed, and the posterior half of its supra-anal plate is covered ventrally with setae, unlike the one figured by Chamberlin, while the

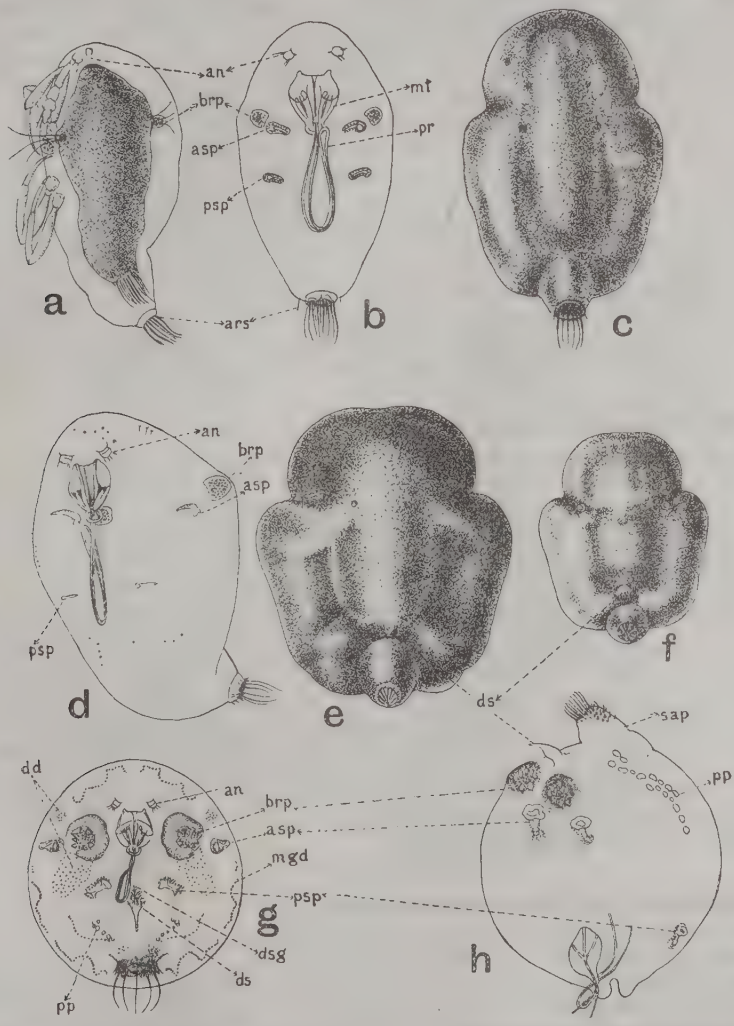


Fig. 14. *L. lacca*, developmental forms of ♀: *a*, 1st stage larva ready to moult, side view, ×60, (partly cleared) ; *b*, early 2nd stage larva, dorsal view, ×65, (cleared) ; *c*, early 2nd stage larva, dorsal view, ×60 ; *d*, advanced 2nd stage larva, ventro-lateral view, ×60, (cleared) ; *e*, advanced 2nd stage larva, dorsal view, ×60 ; *f*, young adult, dorsal view, ×27 ; *g*, young adult, dorsal view, ×25, (cleared) ; *h*, adult, side view, ×15.

number of nuclear ducts in the brachial plates varies from 7 to 10. The antennae are invariably tipped with four long setae ; the two small ones may or may not be seen, though in well-prepared mounts they are distinct.

Previous Observations on Emergence of Larvae (figs. 5, 6).

Stebbing had no clear idea of the reproductive organs of the female lac insect, or as to the time of its survival, as he says "It has been estimated that each female produces as many as 1,000 eggs and as these become mature the mother dies, consisting at that period of life of little more than a skin. This dries and shrivels up after the young larvae have hatched. On hatching the larvae either issue through the anal orifice or through the ruptures of the skin." Imms & Chatterjee profess to have examined the ovary of the female and call the insect viviparous; they say "The fertilised eggs when discharged from the ovaries are found in a large central pouch or vagina." Of the further development or hatching they only say "They [larvae] make their exit chiefly through the anal orifice, but a certain number also find their way out through the spiracular apertures." Lindsay & Harlow say in their report, "Perhaps about a month after being fertilised the female dies; the eggs or young emerge from the body." Green in his description of *Laccifer* (*Tachardia*) *albizziae* says, "As oviposition proceeds, the body contracts and the resulting space is closely packed with ova, the young larvae making their exit through the posterior orifice." Withers & Simmons say in their report on lac in Burma, "The females after coition, after about a month, die. The eggs continue to develop in the dead body of the female for about three weeks before the emergence of the new brood."

The Ovary and its Ducts (fig. 5, *a* to *g*).

The lac insect has two ovaries, as usual, and not one as described by Carter. They practically fill the whole body of the insect. Each ovary comprises a very large number of ovarioles, each consisting of a single follicle, as in other Coccids, and these ovarioles open into the apparently dichotomous branches and sub-branches of the main oviduct of their side, which measures 0·875—1·95 mm. in length. The two main oviducts join two-thirds down the body (*a*) and between them at the junction lies a small pouch or spermatheca in which the spermatozoa are stored. The spermatheca opens into the vagina dorsally (*b*). The common oviduct or vagina opens at the birth-pore or sexual orifice, which lies medially on the ventral side of the posterior extremity of the body about 0·075 mm. in front of the supra-anal plate. The vagina is neither a large central pouch, as described by Imms & Chatterjee, nor are the fertilised eggs discharged into it. It measures 0·75–0·95 mm. in length, and 0·1–0·125 mm. in breadth, at the time when the larvae have begun to emerge from the mother. The walls of the vagina and the oviducts are highly muscular, the muscles being elastic and arranged circularly and longitudinally (*c*, *d*, *e*). The longitudinal muscles do not end with the vagina posteriorly, but their ends are attached to the skin round the sexual orifice (*c*).

The Tergo-sternal and Posterior Sternal Muscles (fig. 5).

From below the posterior end of the brachia of each side six bands of anterior tergo-sternal muscles and three bands of posterior tergo-sternal muscles arise (*f*, *g*). The anterior muscles are the outermost and are symmetrically attached about the middle of the anterior half of the body just outside the anterior sternal muscles. The anterior two bands of the posterior tergo-sternal muscles are symmetrically attached a little behind the middle of the body on the ventral region, just outside the posterior sternal muscles; and the third band of posterior tergo-sternal muscles, which arises from the space between the anterior tergo-sternal muscles and the anterior bands of the posterior tergo-sternal muscles, is attached a little in front of the anal tubercle, at a distance from the sternal muscles. Four pairs of bands of the posterior sternal muscles have their origin from a little behind the middle of the body, two pairs being situated symmetrically on each side; they pass down through the anal tubercle and are attached to the supra-anal plate.

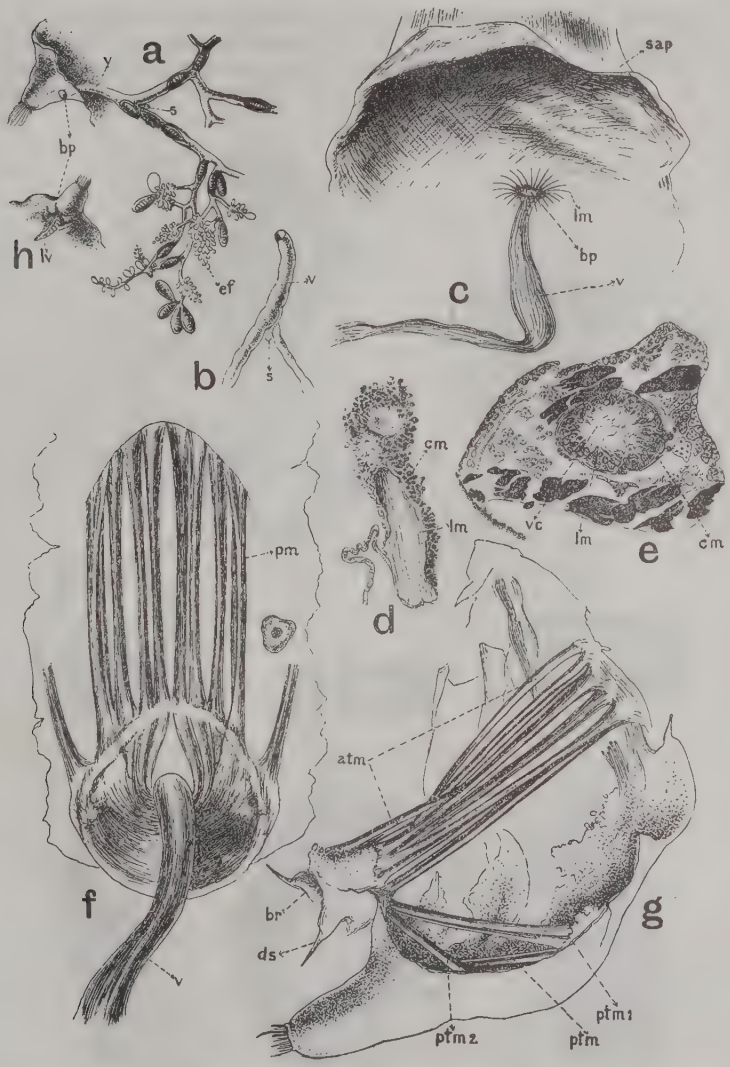


Fig. 5. *L. lacca*: *a*, part of ovary and its ducts, ×10; *b*, spermatheca, ×12; *c*, vagina and the muscular arrangement at birth pore, ×75; *d*, oviduct, longitudinal section, ×150; *e*, transverse section through vagina, ×150; *f*, posterior pleuro-sternal muscles and opening of oviduct, ×60; *g*, arrangement of tergo-sternal and posterior pleuro-sternal muscles, ×32; *h*, larva emerging from birth pore, ×8.

Mechanism of Emergence of Larvae.

When the larvae are nearly mature and are about to be discharged into the oviduct from their follicles, the posterior dorso-ventral or the tergo-sternal muscles contract, and the corresponding sternal region of the body is approximated to the dorsal region of the body above it, with the result that a space, which may be called the incubating

chamber (fig. 6, *d*), is formed between the body of the mother and the lac test on the ventral side below the brachial region. At the same time by the contraction of the posterior sternal muscles the anal tubercle is drawn a little inside the anal orifice in the lac test, and thus a regular free passage is formed between the anal orifice in

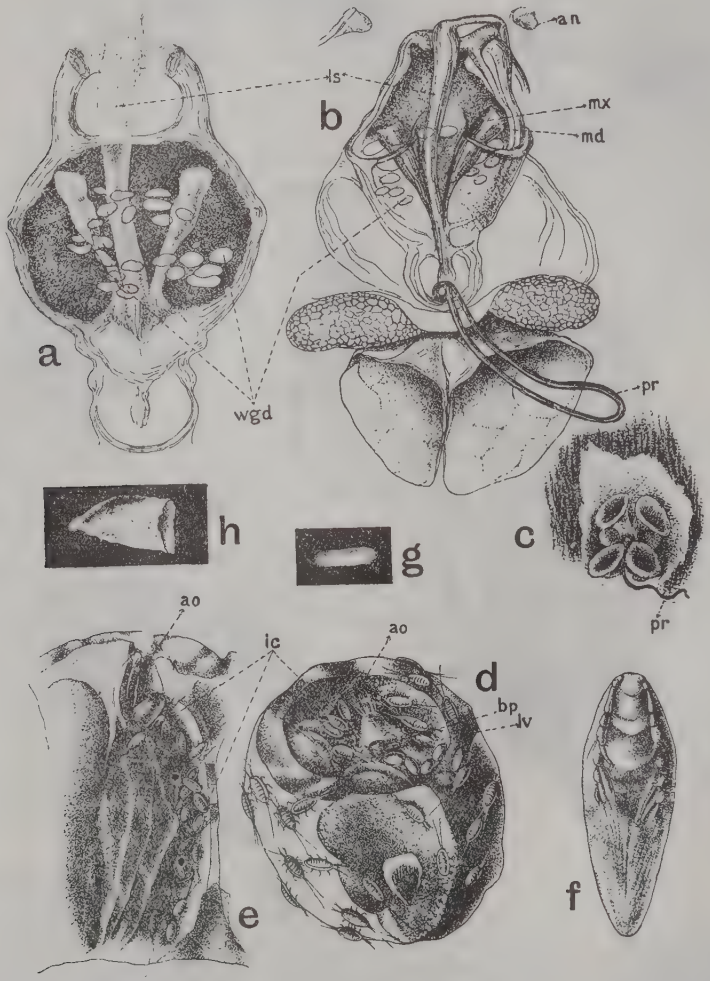


Fig. 6. *L. lacca* : *a*, mouth-parts and wax-gland ducts, dorsal view, ×100, and *b*, ventral view, ×60 ; *c*, mouthparts as seen from ventral side of the test, ×30 ; *d*, early incubating chamber and birth pore, ventral view, ×7 ; *e*, late incubating chamber, lateral view, ×6 ; *f*, newly delivered larva enclosed in film, ventral view, ×50 ; *g*, portion of single wax filament secreted by the perivaginal glands, ×50 ; *h*, film cast from newly hatched larva, ×50.

the lac test and the incubating chamber. This chamber becomes larger later on by the contraction of the anterior tergo-sternal muscles. By this time the perivaginal glands reach their full maturity and are actively functioning by depositing small

and large flocculent filaments of wax into the incubating chamber beneath them. Just when all these preparations have taken place, the eggs containing fully developed larvae, with their posterior end foremost, are discharged from the follicles into the sub-branches and branches of the oviducts of each side, and by contraction and expansion of the circular and longitudinal muscles they pass down, one by one, through the main oviducts of each side, some with their anterior and others with their posterior end foremost to the vagina ; and ultimately they are delivered through the sexual orifice in the incubating chamber. The larva, either with its dorsal or ventral side facing towards the ventral surface of the mother, is delivered in a shorter time with the anterior end foremost (fig. 6, *d*) than with its posterior end foremost (fig. 5, *h*), so that the delivery of the former would appear to be less trying to the mother than that of the latter. Besides this, the larva delivered with its anterior end foremost always casts off the film in which it lies with its appendages unstretched, and with the anal ring setae and the major apical hairs turned over on its ventral surface, in the incubating chamber. It moves its body up and down and the thin film ruptures at the head end, and by further up and down movements the whole larva, with the appendages still unstretched, gradually wriggles out, and the film remains attached to the hitherto turned over anal ring setae and the doubly folded major apical hairs. But the larva which is being delivered with the posterior end foremost, if not followed immediately by another larva, casts off the thin film prior to being fully deposited into the incubating chamber ; and if perchance this period be long enough, it also manages to stretch its appendages in the same interval. After the larva has cast off its film, it tries to stretch its appendages and proboscis by bending its body upwards and downwards among the flocculent filaments of wax and the cast films in the incubating chamber, and is able to do so in about 4–6 hours time. A very large number of larvae are deposited in the incubating chamber before they actually begin to pass through the anal orifice in the lac test to the outside world.

Misra, who has drawn up a very accurate method of foretelling the date of emergence of larvae on the basis of ovarian development, does not seem to have seen the birth-pore and errs in his following statement : " At first the head end of the embryo is directed towards the posterior end of the egg, but as it advances in growth after the appearance of the head and thoracic appendages, it turns round its transverse axis and moves up the oviduct. As soon as it reaches the vaginal opening, the opening in the anal tube, it casts off the thin film enclosing it and moves away in search of a succulent part of the stem to fix itself." As I have said above, the embryo or larva always passes from the follicle to the sub-branch of the oviduct with its posterior end foremost, and it never turns round its transverse axis in the follicle to bring its anterior end foremost. It is only after being deposited into the sub-branch of the oviduct that most of the larvae come to lie with their anterior end foremost ; this is probably effected by the contraction of the circular muscles of the sub-branch of the oviduct, just when the larva is passed from the follicle into it. Neither does the larva cast off its film or egg-case before it is completely or almost completely delivered in the incubating chamber, nor do its appendages get stretched until it has undergone a short period of incubation. In view of these facts Misra's figure (Pusa Bulletin no. 142, pl. viii, fig. 12) would appear to be wrong.

Effect of sudden Cold on the Emergence of Larvae.

It was noticed in several cases that if the emergence of larvae from certain female tests had just begun and sudden rain and cold occurred, emergence stopped for some time. If the weather continues to be unfavourable for two or three days, the larvae will also generally cease emerging from the mother test. To find the effect of cold on the mother which is delivering young ones, the tests of five females were opened just enough to expose the birth-pore and part of the incubating chamber. These female tests were placed on a little plasticine in a sample tube measuring two inches

in length and one inch in diameter and water was poured into the tube up to the level of the basal half of the plasticine platform. Round the basal half of the tube absorbent cotton soaked in ether was wrapped and fanned. At the same time, while looking through the binocular microscope at the females, water was sprayed with a dropper, the basal glass portion of which was covered with absorbent cotton soaked in ether on the inner surface of the sample tube, taking care that no water fell on the test and the exposed part of the females. It was noticed that after a short time, when the atmosphere inside the sample tube was fairly cold, the larvae, which were passing out of the birth-pores, remained stationary, and the other larvae which were in the incubating chamber ceased to move. With two mothers, where there was no emergence from the birth-pore when the atmosphere within the tube suddenly changed, no more larvae were delivered, and the birth-pore was narrowed. The experiment was continued for about forty-five minutes, and it was noticed that during that period not a single larva was delivered by the mothers. The larvae that were held up in the birth-pore remained stationary, and the larvae in the incubating chamber did not stir. After this the mother tests were removed from the cold atmosphere and placed under normal conditions. Five minutes later, it was observed that the larvae in the incubating chamber began to move and shortly afterwards the mothers once more began to deliver the young in quick succession.

From the above it will be clear that the mother insect does not die until practically all the living, fully developed larvae have passed out from her ovaries into the incubating chamber. The mother can control to some extent the emergence of larvae from her body at the time of unfavourable atmospheric conditions by closing the sexual orifice by the contraction of the longitudinal muscles of the oviduct and vagina.

Collection of the Crop.

It will be seen from the above conclusion that it becomes incumbent on the cultivators, in their own interests, to allow the full development of the mother on the host-plant, and to remove the crop (especially that portion to be used as brood lac) not more than 8–12 days prior to the emergence of larvae. The embryo has by this time reached its full development in the ovary of the mother, and the mother thence-forward automatically busies herself in making preparations for delivery. This should allow sufficient time for the big cultivators to arrange for the necessary labour, transit, etc. In addition, cultivators and wholesale buyers get another 3–6 days after emergence has begun for the swarming of the larvae, giving a total period of about a fortnight to make all the necessary arrangements for starting the brood on the trees.

The cultivator should remember that it is extremely harmful to remove the brood lac earlier than the period mentioned above, because the mother does not get the full nourishment ; and though the embryos develop even if the brood lac be removed about a month and a half before the actual emergence of larvae, yet the mother's vitality, without food, goes down considerably, and it makes her almost unfit for the delivery of hundreds of young ones. As experience has shown, the result in such cases is that most of the mothers die without delivering a single young one ; others give birth to only a portion of their young, and these having low vitality when they fix themselves on the plant soon die.

Larval Swarming and Lunar Periodicity.

Mahdihassan, in his observations on the life-histories of the South Indian lac insects, says " Mr. Srinivasayya has made a most important discovery, that the larval swarming is associated with the lunar periodicity ; and the dark half of the month corresponds with the period of intense larval swarming." This would mean

that the larvae begin to emerge from the mother tests generally on or about the full moon, because the " intense larval swarming " generally begins 3–6 days after the emergence has begun. I had the opportunity of examining a fairly large number of brood lac sticks to forecast the emergence of larvae, on the basis of Mr. Misra's ovarian developmental method. The dates of emergence of larvae for both the kartiki (winter) and baisakhi (summer) crop for one year were carefully noted, and the results clearly show that intense larval swarming takes place just as frequently in the moon-lit half of the month as in the dark half. And as the mothers deliver young in the incubating chamber freely during both the dark and the moon-lit periods, I conclude that the lunar periodicity cannot affect the larvae emerging from the tests, which only serve as an incubating chamber and a gathering place for the gregarious young.

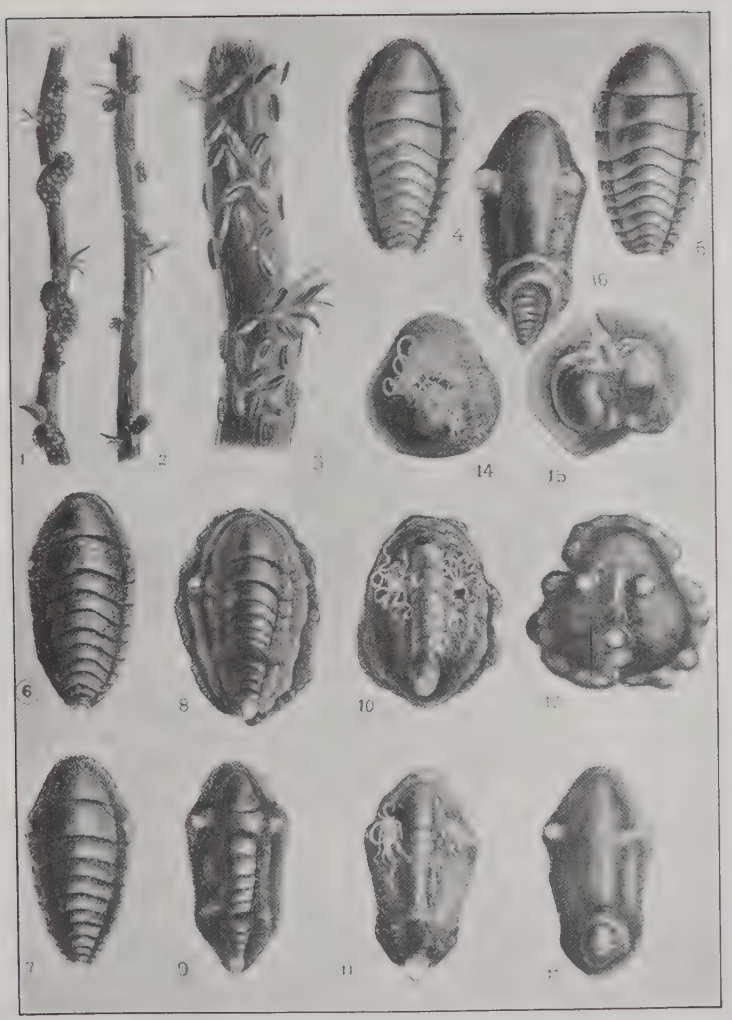
Key to Lettering in Figures.

af	...	Caudal seta.	lv	...	Larva.
an	...	Antenna.	md	...	Mandible.
ao	...	Anal opening.	mgd	...	Marginal ducts.
ars	...	Anal ring setae.	mt	...	Mouth.
asp	...	Anterior spiracle.	mx	...	Maxilla.
atm	...	Anterior tergosternal muscle.	p	...	Penis.
bp	...	Birth pore.	pls	...	Pupal sheath.
br	...	Brachia.	pm	...	Pleurosternal muscles.
brp	...	Brachial plate.	pp	...	Perivaginal pores.
cm	...	Circular muscles.	pr	...	Proboscis.
dd	...	Dorsal ducts.	ps	...	Penis sheath.
ds	...	Dorsal spine.	psp	...	Posterior spiracle.
dsg	...	Dorsal spine glands.	ptm	...	Posterior tergosternal band.
ef	...	Empty follicle.	s	...	Spermatheca.
ic	...	Incubating chamber.	sap	...	Supra-anal plate.
l	...	Leg.	v	...	Vagina.
lm	...	Longitudinal muscles.	vc	...	Vaginal canal.
ls	...	Labial sheath.	wgd	...	Wax-gland ducts.

Explanation of Plate XVI.

Jodhapur Ber Brood Lac from Ber.

Fig. 1. Ber brood lac on ber stem, female tests confluent.
2. Ber brood lac on ber stem, female tests scattered.
3. Bicoloured larvae on ber stem.
4. A pale yellow female larva, dorsal view.
5. A normally coloured female larva (crimson), dorsal view.
6. Female first stage larval test, 2 weeks after inoculation, dorsal view.
7. Male first stage larval test, 2 weeks after inoculation, dorsal view.
8. Female second stage larval test, 3 weeks after inoculation, dorsal view.
9. Male second stage larval test, 3 weeks after inoculation, dorsal view.
10. Young female test, 6 weeks after inoculation, dorsal view.
11. Male prepupal test, 5 weeks after inoculation, dorsal view.
12. Male pupal test, 6 weeks after inoculation, dorsal view.
13. Female test, 8 weeks after inoculation, dorsal view.
14. Adult female test, dorsal view.
15. Adult female test ; cross section behind the anal end showing position of the anal tube and bifid oral lobes.
16. Apterous male emerging from the pupal test.



Jodhapur Ber Brood Lac from Ber.

ON THE RELATIVE VALUE OF PARASITES AND PREDATORS IN THE BIOLOGICAL CONTROL OF INSECT PESTS.

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The factors responsible for the biological control of insect pests fall into three main groups. The first group includes the micro-organisms (Protozoa, Bacteria, and Fungi) producing what is ordinarily called disease; the second comprises the entomophagous insects which lead, during part or all of their life-history (generally during the larval stage only) a parasitic existence, while the third contains a great assemblage of animals of various kinds which agree in being carnivorous in habit and are known as predators. It is difficult to formulate definitions of parasite and predator which are applicable to all cases. The most satisfactory general distinction is perhaps the one recently suggested by E. Rabaud (1928), who restricts the term "parasite" to species which remain permanently attached to a living host, and considers as predators all species which come into contact with the host organism only at feeding time. Each of these categories can be subdivided, according to the effect the parasite or predator exerts upon its host, into sublethal or benignant and lethal or malignant species. Few, if any, of the parasitic entomophagous insects are of the sublethal type, the species whose habits correspond most closely to the definition being perhaps the bee-louse (*Braula coeca*, Nitzsch), which, however, is rather a commensal than a parasite. A few parasitic insects, such as some of the dipterous parasites of Orthoptera and Dermaptera (*Thrixion halidayanum*, Rond., on *Leptynia hispanica*, Bol.— v. Pantel 1897; *Rhacodineura antiqua*, Meig. on *Forficula auricularia*, L.—v. Thompson 1928) do not actually kill their host before issuing, but it dies usually within a relatively short time. In the majority of cases the host is destroyed before the parasite has completed its larval development. Benignant predacious entomophaga are also uncommon among the Arthropods. Certain Chironomids, Simuliids and even Culicids suck the blood of caterpillars, adult dragonflies, moths and butterflies, and other insects, without necessarily killing them (v. Edwards 1923); but, in general, the entomophagous insect and Arachnid predators, being as large as or larger than their hosts, cause death, as do the vertebrate predators.

The parasitic and predacious entomophagous insects thus resemble one another in that they practically always kill their hosts. The question of their relative value as controlling factors is, however, somewhat obscure. That insect predators are numerous and beneficial is, of course, generally acknowledged; but that they are as useful and important as insect parasites is not by any means a universal belief. Thus, the American entomologist, Sanderson, writes that, "Though large numbers of injurious insects are annually destroyed by those which are purely predacious upon them, many more succumb to those minute forms which live parasitically within them." "Most interest in the matter of the biological control of insects," says Herrick, "seems to centre around the use of parasitic forms for this purpose." A reason for the poor opinion in which predators are held by entomologists is given by Howard and Fiske. "These predators," write the authors in question, "are not directly affected by the abundance and scarcity of any single item in their varied menu. Like all other creatures they are forced to maintain a relatively constant abundance among other forms of animal and plant life, and since their abundance from year to year is not influenced by the abundance or scarcity of any particular species of insect among the many upon which they prey, they cannot be ranked as elements in the facultative control of such species. On the contrary, it may be considered that they average to destroy a certain gross number of individuals each

year, and since this destruction is either constant, or, if variable, is not correlated in its variations to the fluctuations in abundance of the insect preyed upon, it would most probably represent a heavier percentage when that insect was scarce than when it was common. . . . A mutual balance can only be maintained through the operation of facultative agencies which effect the destruction of a greater proportionate number of individuals as the insect in question increases in abundance."

Since the attempts to utilise the parasitic and predacious enemies of insect pests are becoming increasingly numerous, it seems desirable to subject all the fundamental assumptions of this work to a careful and critical examination. I therefore propose to consider in this paper the relative value of parasites and predators in the biological control of their insect hosts.

In order to restrict the field of enquiry to organisms of a reasonably comparable type, only insect parasites and predators will be considered. The bionomics of the Nematodes, Arachnids and Myriapods which prey upon insects are so little known that they can scarcely be discussed with any profit at present. The literature concerning the vertebrate predators, particularly birds, is enormous, but it contains, unfortunately, relatively little data of the type necessary in order to evaluate the importance of these organisms. That they exert some effect in limiting insect increase is certain; that they are factors of major importance is not proven; that they are capable of reducing severe outbreaks is extremely doubtful. In his excellent book on Animal Ecology, Elton (1927) points out that large organisms tend in general to increase much less rapidly than small ones, and that on this account they are unable to keep pace with an outbreak of one of the smaller species on which they prey. It is true that in some cases vertebrate predators tend to concentrate in numbers at the point where an outbreak has occurred and tend to feed chiefly upon the abundant species, even though this involves a decided change of habits. However, even leaving aside the question as to the injury resulting by the abandonment of the other injurious species normally attacked, which are now freed from one of their controlling factors, it is not by any means certain that the concentration exerts a decisive influence or even that it occurs before the host species is already so numerous that it can no longer be checked. In any event, aside from the benefits that may be derived from the protection of the vertebrate enemies of insects, there seems little likelihood that they can be utilised practically. I therefore need not discuss them further for the present.

Considering then the relative value of insect predators and parasites the first point that strikes one is that predacious species are much more varied in structure, habits, and distribution than are the parasitic species, since they occur in a much greater number of orders, families and genera. Parasites on insects occur in the families STAPHYLINIDAE, RHIPIPHORIDAE and MELOIDAE of the order Coleoptera, in the order Strepsiptera, of which all the members are parasites on Aculeate Hymenoptera and Homoptera; in the families MANTISPIDAE and ITHONIDAE in the Neuroptera; in the families EPIPYROPIDAE and CYCLOTORNIDAE (Tillyard, 1926) among the Lepidoptera; in the families CECIDOMYIIDAE, NEMESTRINIDAE, ACROCERIDAE, BOMBYLIIDAE, PHORIDAE, PIPUNCULIDAE, CONOPIDAE and MUSCIDAE (sens. lat.) among the Diptera; and in the families ORYSSIDAE, ICHNEUMONIDAE, BRACONIDAE, TRIGONALIDAE, AULACIDAE, STEPHANIDAE, EVANIIDAE, PROCTOTRUPIDAE, CYNIPIDAE, CHALCIDIDAE, CLEPTIDAE, CHRYSIDIDAE, TIPHIIDAE, MUTILLIDAE, SCOLIIDAE, BETHYLIDAE, RHOPALOSOMIDAE, DRYINIDAE and APIDAE (sens. lat.) among the Hymenoptera.

Predacious entomophagous insects occur, however, in a much greater number of groups. Listing only terrestrial and aerial predators, we find insect-eating species in the families MANTIDAE, TETTIGONIIDAE and GRYLLIDAE, among the Orthoptera; in the families RHAPHIDIIDAE, MANTISPIDAE, HEMEROBIIDAE, CHRYSOPIDAE, PSYCHOPSIDAE, NEMOPTERIDAE, MYRMELEONIDAE, ASCALAPHIDAE and CONIOPTERYGIDAE, among the Neuroptera; in the Odonata, which are all predacious; in the

Corrodentia, of which certain species such as *Ectopsocus briggsi*, McL., and other members of the genus attack Coccids (Kirkpatrick 1927); in the Thysanoptera, of which a number are predacious on Coccids, Aphids, Tingids, weevil larvae, Lepidopterous larvae, other Thysanoptera and Red Spiders; in the families PENTATOMIDAE, PYRRHOCORIDAE, PHYMATIDAE, REDUVIIDAE, ANTHOCORIDAE, LYGAEIDAE, SALDIDAE and CAPSIDAE, among the Hemiptera; in the order Dermaptera, of which many species are at least partly carnivorous; in the families CICINDELIDAE, CARABIDAE, RHYSODIDAE, STAPHYLINIDAE, SILPHIDAE, HISTERIDAE, NITIDULIDAE, CUCUJIDAE, COLYDIIDAE, COCCINELLIDAE, CANTHARIDAE, MELYRIDAE, CLERIDAE, ANTHRIBIDAE, CRYPTOPHAGIDAE, MORDELLIDAE, MELOIDAE, ELATERIDAE and BRENTHIDAE, among the Coleoptera; in the Mecoptera; in the TINEIDAE and NOCTUIDAE among the Lepidoptera; in the families CHIRONOMIDAE, CECIDOMYIIDAE, SIMULIIDAE, XYLOPHAGIDAE, COENOMYIIDAE, LEPTIDAE (or RHAGIONIDAE), TABANIDAE, THEREVIDAE, SCENOPINIDAE, ASILIDAE, MYDAIDAE, DOLICHOPODIDAE, EMPIDIDAE, SYRPHIDAE and MUSCIDAE (sens. lat.) among the Diptera; and in the TENTHREDINIDAE, POMPILIDAE, FORMICIDAE, VESPIDAE, AMPULICIDAE and SPHEGIDAE, among the Hymenoptera. Predators are thus found in almost twice as many families as parasites and are probably represented in nature by a greater number of species, though it is difficult to arrive at any reliable estimate.

The idea that predators are less reliable than parasites is due chiefly to the belief that they are less specific in their choice of hosts. This belief probably has its origin in the fact that predacious insects are mobile during the predacious stages and are frequently seen in the act of moving from one host to another, while parasites remain permanently in contact with the host during the whole of the parasitic stage. The association of the parasite with its host is thus *apparently* more intimate since a given individual is always found during the parasitic period on or in a given species of host, whereas the predator may feed upon hosts of several different species before completing its development; it is thus rather natural to suppose its host relations are less specific than those of the parasite. This supposition I believe to be incorrect. The specificity of the enemies of insects depends primarily, not upon the number of opportunities they have to change their hosts, but upon their natural affinities. If a given parasite is attracted only by a single species of host, it will not attack others, no matter how frequently it may encounter them. Even the most polyphagous organisms utilise as food only a very few of the enormous number of species found in the areas they inhabit. They are restricted in their host relations not because few hosts are available but because few of the available hosts attract them. The fact that an adult or larval predator devours a number of hosts and moves from one individual to another while the larval parasite remains throughout its life in the same host does not mean that the predator will attack a greater number of species than the parasite. Many predators deposit their eggs in close proximity to certain hosts, being just as specific in their oviposition as the dipterous parasites having similar habits. Again, although the larval parasite cannot move from one species to another, the adult parasite can do so and could in fact attack as many species of hosts as it has eggs to deposit. It might be suggested that the parasite which has passed the whole of its larval life in a single host will tend to select that species of host at oviposition; but one might equally well suppose that the first species of host attacked by a predator is likely to be chosen at subsequent feedings.

In point of fact, there appears to be relatively little difference in the specificity of parasites and predators. Few parasites are strictly monophagous and, as Imms (1925) points out, the numbers of species placed in this category diminishes from year to year as their biology becomes better known. On the other hand, there is no doubt that many predators are more specific in their choice of hosts than has been supposed. This has been well shown by F. A. & M. Schilder (1928) in their valuable work on the food of Coccinellids. Thus the HYPERASPINI feed mainly on Coccids,

the HIPPODAMIINI mainly on Aphids, the MICROWEISEINI attack chiefly Diaspine scales, the AZYINI those of the *Lecanium* group. The genera *Rodolia* and *Novius* among the EXOPLECTRINI specialise on *Icerya*; *Scymnus discoideus* attacks Aphids; *S. adspersus* and *coloratus* feed on *Pseudococcus*; *S. coccidivora* on *Pulvinaria*. Among other predacious Coleoptera, the large Carabids feed mainly on large lepidopterous larvae; some species of the Staphylinid genus *Stenus* feed chiefly on Collembola (Elton *loc. cit.*), the Nitidulid, *Rhizophagus*, feeds on xylophagous coleopterous larvae; the carnivorous Syrphid larvae are for the most part enemies of Aphids; among the Heteroptera the Asopine Pentatomids attack principally lepidopterous and coleopterous larvae. Among the Neuroptera, the Chrysopids feed mainly on Aphids. Among the Sphegoid Hymenoptera *Lyroda subita* provisions its nest with crickets, *Misopus* and *Trypoxylon* with spiders, *Ammophila* with caterpillars.

A great deal more work certainly needs to be done on the host relations of predacious insects. What we already know is, however, sufficient to prove that they are at least relatively restricted in their choice of food, and since this is the most we can say of parasitic insects of which many are extremely polyphagous, the average predator cannot on the score of specificity be considered as markedly inferior to the average parasite.

Whether oligophagous or polyphagous parasites and predators are markedly inferior to monophagous parasites and predators in the control of injurious insects and in the reduction of their outbreaks is an entirely different question. Many entomologists consider polyphagous species to be of relatively little value in reducing outbreaks. This is the view of Howard and Fiske, expressed in the quotation given above. "Since their abundance from year to year is not influenced by the abundance or scarcity of any particular species of insect among the many upon which they prey," write these authors, "they cannot be regarded as elements in the facultative control of such species." This criticism appears to me to be unjustified. If an increase in the numbers of its host produces an increase in the numbers of a monophagous parasite or predator, an increase of any one of the hosts of a polyphagous parasite or predator ought to have the same effect, other things being equal. Until an abnormal increase of one of the species it attacks occurs, the polyphagous species will distribute its progeny among its several hosts in proportions depending upon its individual preferences and the relative numbers of each species available. If one of its hosts begins to increase, that particular host will tend to receive a greater proportion of eggs or larvae, unless it is only slightly attractive. An increase of the host will, of course, be followed by an increase of its enemies only when the multiplication of the latter has been limited chiefly by the scarcity of hosts. When this is the case, as it evidently is in some instances, a polyphagous species will increase in just the same way as a monophagous species. As the particular host which is on the increase becomes more numerous, it will receive a greater and greater proportion of the progeny of the beneficial species. However, even if a considerable proportion of the offspring of the latter continues throughout the whole course of the outbreak to be placed in hosts of secondary importance, the effect of this will be much less important than one might suppose. The species with this habit will, in fact (other things being equal), be exactly comparable to parasites like the gregarious Hymenoptera and Diptera which deposit large numbers of eggs or larvae in a single host, and destroy only a small number of their prey, even though they produce a large number of descendants. This point will be discussed more fully a little later in this paper.

A point of considerable importance in considering the relative values of parasitic and predacious insects concerns the reproductive rates. Very little accurate information regarding this aspect of the matter is available. We know that certain parasites, such as the Acrocerid Diptera and some of the Tachinids, produce enormous numbers of eggs. Nothing comparable seems to have been recorded for any of the predators. However, the method of oviposition of the parasites mentioned is so

extremely wasteful that very few of their progeny reach maturity except perhaps under extremely unusual circumstances. The species with high reproductive rates are thus not necessarily the most effective. There is not, so far as we know, any striking difference in the *effective* rates of reproduction of parasites and predators.

Even if predacious insects were less specific and also less prolific than parasitic insects, these disadvantages would be outweighed by the fact that each individual predator devours a large number of host insects during its existence, while the parasite destroys at best only one and in many cases does not even accomplish this much, since, as has already been pointed out, there are many species of parasites which deposit a large number of eggs or larvae in a single specimen of the host species. In some cases of this type several scores of larvae devote themselves to the destruction of each host attacked. It is true that the female of certain hymenopterous parasites such as *Microbracon, Exeristes, Habrocytus* and others, have been observed to feed upon the blood or flesh of the host. This habit is no doubt more general in the parasitic Hymenoptera than has been supposed ; but we have no proof that it is of any great importance or that parasites in general act as predators in the adult stages.

On the other hand, it is certain that many predacious insects destroy large numbers of individuals of the species on which they prey during the course of their life-history. According to Metcalf (1916–17) a larva of *Syrphus nitens*, which had not previously been fasting, caught and destroyed, under normal conditions, 21 individuals of the Aphid *Pterocomma flocculosa* in 20 minutes. Clausen (1916) states that *Hippodamia convergens*, Guér., consumes on an average 21 Aphids a day during larval life, and *Coccinella californica*, Man., about 25, the total number consumed during the whole of the life-history being from 234 to 624 in different species. According to Simanton (1916), the Coccid-feeding lady-bird *Hyperaspis binotata* can destroy as many as 90 adults and 3,000 larvae during its larval life. Burgess (1911) states that a larva of *Calosoma sycophanta* will devour on the average 41 full-grown caterpillars of the gipsy moth ; young adults consume an average of 238 caterpillars, old adults an average of 272. Three pairs of beetles fed on young larvae of the brown-tail moth devoured about 6,000 of the caterpillars.

In order to make clear the significance of this point, let us calculate the length of time necessary for the annihilation of a given host population by given populations of gregarious parasites, solitary parasites and predators.

Let the initial population of the host species be $=n$, the initial population of the parasite or predator be $=p$, and let the sex ratios of the host and its enemies be equal.

Suppose, to begin with, that the effective reproductive rate of the parasites and predators is equal to those of the host.

It can then be shown, by mathematical methods which have been explained in detail in several earlier papers, that the time, t, in generations, necessary for the extermination of the host by the parasite or predator reproducing at its expense, is given by the following formulae.

(1) Each offspring of the beneficial insect destroys one individual of the host species, as in the case of the typical "solitary parasite." The time required for control is then :—

$$t_1 = \frac{n}{p}$$

(2) Each offspring of the beneficial insect destroys r individuals of the host species as in the case of the ordinary mobile predators. The time required for control is then :—

$$t_2 = \frac{n - p\,(1-r)}{pr}$$

(3) Several offspring of the beneficial insect are required to kill a single host, as in the case of such gregarious parasites as *Apanteles, Microbracon, Macrocentrus, Pteromalus,*

etc. Let the number of parasite larvae ordinarily required to destroy one host be $=m$. The time required for control is then :—

$$t_3 = \frac{mn - p\,(m-1)}{p}$$

For any value of n and p the value of t_1 is of course a constant. The value of t_2 varies inversely as the value of r and that of t_3 directly as the value of m. An entomophagous species laying twice as many eggs as another in each individual host will take twice as long to bring it under control, other things being equal; a species devouring twice as many hosts as another in the course of its life-history will require only half the time to bring it under control.

Other things being equal, a predator which devours 100 hosts during the course of its life-history will thus reduce an outbreak 100 times as fast as a solitary parasite or 1,000 times as fast as a gregarious parasite which deposits 10 eggs in each host attacked; providing always that the reproductive rates of the host and enemy are equal.

Let us suppose that the feeding period of the predator occupies 10 days and that during these 10 days it devours 100 hosts. To do this it would have to devour only one host every $2\frac{1}{2}$ hours. If the actual process of feeding occupies 10 minutes, the chance of finding the predator in the act of devouring its host would be less than one in a thousand for an observation lasting one minute, or less than one in one hundred for an observation lasting ten minutes. On the other hand in ten minutes one might easily collect one hundred caterpillars, and no matter at what moment these caterpillars were collected, any parasites present would certainly be found, since they are permanently associated with the host during larval life. In ten minutes work one would thus be practically certain of finding a parasite destroying only one per cent. of the population, but would have less than one chance in a hundred of finding a predator capable of destroying 100 per cent. of the population. This statement of the case may perhaps seem a little exaggerated, but I think that it gives a fair idea of the difficulty of detecting the work of predators and estimating its importance, as compared with that of parasites.

If the beneficial insect reproduces more rapidly than the host insect, let the reproductive rate of the first be $=s$, of the second $=h$ (these symbols denoting the number of progeny surviving to reproduce in each generation) and let $s=ah$, $(a > 1)$.

Our equations will then become :—

$$t_1 = \frac{\log\left(\frac{na-n+pa}{pa}\right)}{\log a}$$

$$t_2 = \frac{\log\left(\frac{na-n+par}{par}\right)}{\log a}$$

$$t_3 = \frac{\log\left(\frac{mn\,(a-1)+pa}{pa}\right)}{\log a}$$

For any fixed values of n, p and a, t_1 is thus a constant; t_2 varies inversely as the logarithm of r, and t_3 varies directly as the logarithm of m. Therefore while the difference in the effectiveness of the organisms considered is of the same general type as in the preceding case, it is much less marked; all the beneficial organisms concerned being, however, much more effective as controlling factors.

Putting $n=1000$, $p=1$, $a=2$, and giving r and m successive values from 1 to 9 we obtain the following results :—

r or m	t_1	t_2	t_3
1	8·9	8·9	8·9
2	—	7·9	9·9
3	—	7·3	10·5
4	—	6·9	10·9
5	—	6·6	11·2
6	—	6·3	11·5
7	—	6·1	11·7
8	—	5·9	11·9
9	—	5·8	12·1

If the reproductive rates of the beneficial insect is less than that of the host, so that we have $as=h$, $(a > 1)$ our equations will be :—

$$t_1 = \frac{\log\left(\frac{p}{n-na+p}\right)}{\log a}$$

$$t_2 = \frac{\log\left(\frac{pr}{n-na+pr}\right)}{\log a}$$

$$t_3 = \frac{\log\left(\frac{p}{mn\,(1-a)+p}\right)}{\log a}$$

The equation for t_1 can be solved only when the value of p is greater than that of $n\,(1-a)$, which is of course always a minus quantity. Thus if the reproductive rate of the host is twice as great as that of the parasite or predator, control can be effected only if there are more parasites or predators than hosts ; if the reproductive rate of the host is three times as great as that of the parasite, there must be more than twice as many parasites as hosts ; if the reproductive rate of the host is one and a half times as great as that of the parasite, there must be more than half as many parasites as there are hosts.

When the host reproduces more rapidly than the parasite, the latter is therefore not capable of reducing an outbreak if its population at the onset is very small in comparison with that of the host.

The habit of devouring numerous hosts in the course of the life-history, which is characteristic of predators, has an important effect in compensating for a low reproductive rate. As an examination of the equation for t_2 will show, it can be solved provided the value of pr is greater than that of $n\,(1-a)$. The size of the parasite population necessary to produce control thus varies inversely as the value of r, i.e. according to the number of hosts devoured in the life history. A predator devouring two hosts need only be half as numerous and one devouring ten hosts only one-tenth as numerous as a parasite devouring only one, in order to be an effective controlling agent. A relatively low rate of reproduction is thus not necessarily a bar to effective and rapid action in a predator.

On the contrary, the habit of depositing a large proportion of the progeny in a single host, after the manner of the gregarious Entomophaga, renders the parasite with a low reproductive rate very much less efficient. A solution of the equation for t_3 is possible only when we have values of p greater than those of $mn\,(1-a)$. The size of the parasite population necessary to produce control thus varies directly as the value of m. A parasite depositing 2 eggs in a single host must be more than twice as numerous, and one depositing 10 eggs in a single host more than ten times as numerous as a parasite depositing only one, in order to effect control. The inefficiency of such species as compared with predators is evident.

The conclusions concerning the value of predacious insects to which one is led by theoretical considerations are strongly supported by the history of practical work in biological control. The ladybird *Novius cardinalis* has been found everywhere to be a perfect remedy for the fluted scale. *Cryptolaemus* is bred on a commercial scale in California for use against the *Citrophilus* mealybug with great success. *Calosoma sycophanta* was said by Burgess and Collins to be, in 1914, the most important biological factor of control then acting upon the gipsy moth in New England. The introduction of the Capsid bug, *Cyrtorhinus mundulus*, Bred., seems to have proved a definite solution of the problem of the sugar-cane leaf-hopper in Hawaii. Metcalf and Patch (*v.* Metcalf, *l.c.*) consider the Syrphid, *Pipiza pisticoides*, Will., to be the most important enemy of the woolly aphis of the apple in Maine. These facts suffice to show the importance of predators as agents of biological control.

I do not wish to give the impression that I believe all predators, or even all insect predators, to be more efficient than any parasites in controlling the ravages of injurious insects. The relative importance of these two types of controlling agencies in any given case can only be decided by careful investigation in the field. I do, nevertheless, believe that the part played by predacious insects has been underestimated; that they are worthy of more careful attention than they have generally received, and that the possibility of their utilisation in practical entomological work is considerable.

References.

Burgess, A. F. 1911. *Calosoma sycophanta*, its life-history, behaviour and successful colonization in New England.—U.S. Dept. Agr., Bur. Ent., Bull. no. 101.

Burgess, A. F. & Collins, C. W. 1915. The Calosoma beetle (*Calosoma sycophanta*) in New England.—U.S. Dept. Agr., Bur. Ent., Bull. no 251.

Clausen, C. P. 1916. Life-history and feeding habits of a series of California Coccinellidae.—Univ. Calif. Tech. Publ. i, no. 6, pp. 251–299. Berkeley, Cal.

Edwards, F. W. 1923. New and old observations on Ceratopogonine Midges attacking other insects.—Ann. Trop. Med. & Parasit., Liverpool, xvii.

Elton, C. 1927. Animal Ecology, London.

Herrick, G. W. 1925. Manual of Injurious insects, New York.

Howard, L. O. & Fiske, W. F. 1912. The importation into the United States of the parasites of the Gipsy Moth and the Browntail Moth.—U.S. Dept. Agric., Bur. Ent., Bull. no. 91.

Imms, A. D. 1925. A general text book of entomology. London.

Kirkpatrick, T. W. 1927. The Common Coffee Mealy-Bug in Kenya Colony.—Dept. Agric. Kenya, Nairobi, Bull. no. 18.

Metcalf, C. L. 1916–17. Syrphidae of Maine, Maine Agr. Exp. Sta., Bulls. 253 and 263. Orono, Me.

Pantel, J. 1897. Le *Thrixion halidayanum* Rond.—La Cellule, xv.

Phillips, E. F. 1925. The bee-louse, *Braula coeca*, in the United States.—U.S. Dept. Agric., Dept. Circ. 334.

Rabaud, E. 1928. Parasitisme et Evolution.—Revue Philosophique, Paris, cv.

Sanderson, E. D. 1902. Insects injurious to staple crops. New York and London.

Schilder, F. A. & Schilder, M. 1928. Die Nahrung der Coccinelliden und ihre Beziehung zur Verwandtschaft der Arten.—Arb. biol. Reichsanst., Berlin, xvi.

Simanton, F. L. 1916. *Hyperaspis binotata*, a predatory enemy of the Terrapin Scale.—J. Agric. Res., Dept. Agric., vi, no. 5, Washington, D.C., pp. 197–203.

Thompson, W. R. 1928. A contribution to the study of the Dipterous parasites of the European Earwig.—Parasitology, xx, no. 2.

Tillyard, R. J. 1926. The Insects of Australia and New Zealand. Sydney, Australia.

A NEW SPECIES OF *NYSIUS* (HEM., LYGAEIDAE) FROM AUSTRALIA.

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The Rutherglen bug is a well-known pest of fruit trees, vines and other crops in Australia, and has been recorded from every State in the Commonwealth, even Western Australia not being free from it.

The identity of this insect has been uncertain for some time past, although it has been assumed in economic literature that the species described by Bergroth in 1891 as *Nysius vinitor* is identical with the Rutherglen bug, since it is the only representative of the genus *Nysius* to have been described from Australia.

In 1927 Mr. R. Veitch, Chief Entomologist of the Department of Agriculture and Stock, Brisbane, sent a collection of *Nysius* spp. to the Imperial Bureau of Entomology for determination. They were handed over to Mr. W. E. China, of the British Museum, to whom I am indebted for the very considerable assistance given me in the preparation of this paper.

The collection, which consisted of a number of insects off different plants and from various localities, contained two distinct species, one of which agreed with Bergroth's very inadequate description of *N. vinitor* (I have not seen the type); the other turns out to be a new species, which I propose to name *Nysius clevelandensis*, since all the locality labels of this insect were marked Cleveland.

Nysius clevelandensis, sp. nov.

Colour variable, from testaceous mottled with fuscous to black. Length, 3–4 mm. (from front of head to apex of hemielytra).

Head (fig. 1) black, slightly pubescent; punctate between the eyes, the pits usually being arranged in six longitudinal rows, although when the head is very hairy it seems to bear three longitudinal pale stripes. Antennae variable in colour, the base of the second segment often being black. Tylus black, narrow. Bucculae long,

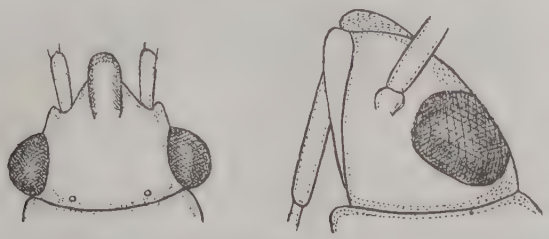

Fig. 1. Head of *Nysius clevelandensis*, sp. n.

nearly reaching the base of the head. Rostrum terminating between the hind coxae, the first segment passing the bucculae. Beneath, between the eyes, on both sides, an oblong sub-oblique pale spot. *Pronotum* covered with fine pale hairs (sometimes only slightly), deeply punctate; anterior margin often rufescent; subapical transverse line black. *Scutellum* hairy. *Hemielytra* hyaline. Costal margin of corium (fig. 2, *a*) straight anteriorly; from a point in line with the apex of the scutellum the margin curves gradually posteriorly. Corium and clavus hairy, especially the front of the

costal margin. Posterior margin of corium fuscous, twice interrupted by yellow bars. Hemielytra extending just beyond the apex of the abdomen. *Legs* testaceous, usually spotted with black. *Genital segment* hairy ; male genital clasper as in fig 2, *b*.

Described from 22 specimens taken on *Sonchus oleraceus*, *Gnaphalium purpureum*, and *Erigeron linifolius*, at Cleveland, Queensland.

Type in the British Museum.

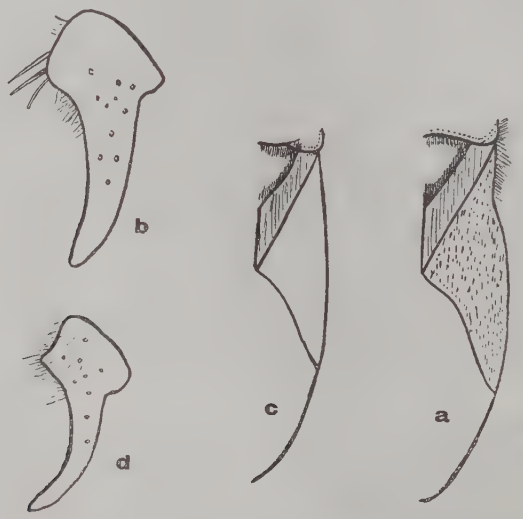

Fig. 2. *Nysius clevelandensis*, sp.n. ; *a*, corium and clavus ; *b*, male genital clasper. *N. vinitor*, Bergr : *c*, corium and clavus ; *d*, male genital clasper.

Bergroth's description of *Nysius vinitor* rests mainly on colour characters, in spite of the fact that it commences by stating that the colour is variable ; so in order that the two Australian species of the genus *Nysius* may not be confused, I give below a re-description of *N. vinitor*.

Nysius vinitor, Bergroth.

Colour variable, mainly testaceous, rufescent and black. Length 3–4 mm. (from front of head to apex of hemielytra).

Head dark, apex and inner margins along eyes usually rufescent, with a pale spot in the middle of the posterior margin, which sometimes extends to the pronotum. Surface slightly punctate, the pits being shallow and difficult to distinguish ; slight pilosity usually present. Antennae variable in colour, the base of the second segment always being pale. Tylus wide anteriorly ; rufescent in middle and edged with black (fig. 3). Bucculae short, not nearly reaching the base of the head. Rostrum passing beyond hind coxae, the first segment being longer than the bucculae. Beneath, between the eyes, on both sides an oblong sub-oblique yellow spot. *Pronotum* with anterior third usually black, the rest testaceous ; finely pilose and with shallow punctures which are generally fuscous, seldom black. *Scutellum* black, pilose. *Hemielytra* hyaline, extending well beyond the apex of the abdomen ; corium

(fig. 2, *c*) with an even costal margin, its posterior margin fuscous, twice interrupted with yellow bars. *Legs* testaceous, usually spotted with black. *Genital segment* glabrous ; male genital clasper as in fig. 2, *d*.

The specimens from which this description was taken bore labels of various localities in Queensland, but none of them came from Cleveland.

The two species described above are very similar in general appearance, but can immediately be separated on the characters of the bucculae and the costal margin of the corium, and if examined with a hand lens, *N. vinitor* appears to be glabrous, while *N. clevelandensis* is hairy. Colour characters are useless for specific identification in this genus.

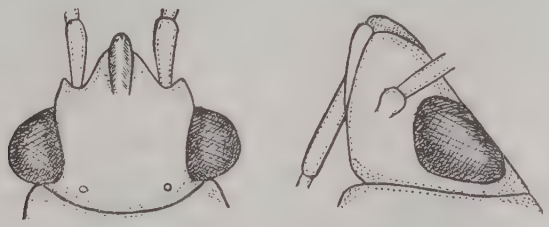

Fig. 3. Head of *N. vinitor*, Bergr.

While examining the collection of the British Museum in order to make certain that neither of the above-described species were insects that had been introduced into Australia, I was struck by the confusion existing within the genus *Nysius*, for although Horváth, Kirkaldy and Stål have each erected certain subgenera, yet still various species are included under *Nysius* that bear characters quite distinct from the genotype, *N. thymi*, Wollf.; and to add to this confusion, Kirkaldy (Fauna Hawaiiensis, ii), while recognising some new subgenera, preferred to unite all the species under one genus. The subgenera of *Nysius* can however be regarded as perfectly valid genera, and the following key will serve to distinguish those formerly included under *Nysius*, auctt.

Key to Genera included under Nysius, *auctt.*

1. Hemielytra usually strongly abbreviated, rarely complete, in which case the two interior veins of the membrane are not joined by a cross-vein 2
   Hemielytra always complete ; two interior veins of membrane joined by a cross-vein 3
2. Apex of scutellum broadly rounded, abdomen ovate (dilated laterally) ; lateral margins of pronotum convergent anteriorly *Nithecus*, Horváth. (Type *N. jacobeae*, Schill.)
   Apex of scutellum angular ; abdomen elongate (not dilated laterally) ; pronotum more or less parallel-sided ... *Hudsona*, g. n. (Type *N. anceps*, B. W.)
3. Posterior margin of metapleuron straight, the posterior lateral angle ninety degrees, not rounded 4
   Posterior margin of metapleuron sinuate, the posterior lateral angle less than ninety degrees, rounded 5
4. Pronotum with lateral margins strongly convergent anteriorly ; median length greater than width of anterior margin ; rostrum not passing hind coxae ; broad dull species ... ... *Myersia*, g. n. (Type *N. clavicornis*, F.)
   Pronotum with lateral margins more or less parallel-sided ; median length less than width of anterior margin ; rostrum extending beyond hind coxae ; elongate shining species *Oceanides*, Kirk. (Type *N. nimbatus*, Kirk.)

5. The whole insect glabrous; rostrum extending almost to middle of abdomen; posterior lateral angle of metapleuron produced into an angular lobe; lateral angle of pronotum suddenly rounded before anterior margin
Neseis, Kirk. (Type *N. monticola*, Kirk.)

The whole insect not glabrous; rostrum not reaching middle of abdomen; posterior lateral angle of metapleuron variable, but not produced into an angular lobe; lateral angle of pronotum not suddenly rounded before anterior margin 6

6. Costal margins of hemielytra straight throughout, parallel or converging posteriorly. Eyes prominent; exposed area behind the eyes greater than half width of eyes; bucculae less than half the length of the gular area
Ortholomus, Stål. (Type *N. punctipennis*, H. S.)

Costal margins of hemielytra straight only at base, if at all; eyes not so prominent; bucculae variable ... *Nysius*, Dallas. (Type *N. thymi* Wollf.)

Further Notes.

1. Horváth's subgenus *Anorthus* (type *N. atlantidum*) has not been included in the key, as the British Museum possesses no representatives of this group. He defines it as possessing the following characters: Body slightly hairy; gula shorter than the bucculae; first joint of rostrum reaching distinctly beyond the bucculae. The base of the costal margin of the corium straight, thence suddenly widely rounded; membrane extending slightly beyond the apex of the abdomen.

2. Of the Hawaiian fauna, only two species can be placed in the genus *Nysius*; these are *N. coenosulus*, Stål, and *N. delectus*, B. W.

3. *N. novitius*, Distant, from the Transvaal, has been placed in the wrong genus, and even in the wrong subfamily. It belongs to the genus *Aphanus*, subfamily APHANINAE.

4. Kirkaldy (1909) wrongly refers *N. anceps* to *Nithecus*.

References.

BERGROTH, E. 1891. On the new Australian Vine Pest.—Ent. Mon. Mag, xxvii.
STÅL, C. 1874. Enumeratio Hemipterorum, iv, pp. 119–122.
HORVÁTH, G. 1890. Synopsis de *Nysius* paléarctiques.—Rev. d'Ent., ix.
HORVÁTH, G. 1895. Hémiptères nouveaux d'Europe et des pays limitrophes.—Rev. d'Ent., xiv.
KIRKALDY, G. W. 1901. Fauna Hawaiiensis, ii, pt. 6.
KIRKALDY, G. W. 1909. A list of Hemiptera of the Maorian Subregion.—Trans. N.Z. Inst., xli, pp. 22–29.

PUPAL PARASITES OF *HOLCOCERA PULVEREA*, MEYR. (LEP.), AN ENEMY OF THE LAC INSECT.

By S. Mahdihassan.

Caterpillars of the moth *Holcocera pulverea*, Meyr., along with those of *Eublemma amabilis*, Moore, do great damage to lac cultivation by feeding upon the living insects. Misra* and Imms & Chatterjee† have pointed out that *H. pulverea* may be found in even greater numbers than *E. amabilis*, though the predacious nature of the latter is more generally recognised. I have been able to confirm this observation with North Indian species of lac insects growing on *Butea frondosa* and *Schleichera trijuga*. However, in South India the wild species of lac, *Lakshadia communis*, at least in Mysore, is entirely free from the attack of *H. pulverea*, while *Lakshadia mysorensis*, the species commercially cultivated on *Shorea talura*, is never attacked by *H. pulverea* to the same extent that it is by *Eublemma amabilis*. With *L. mysorensis*

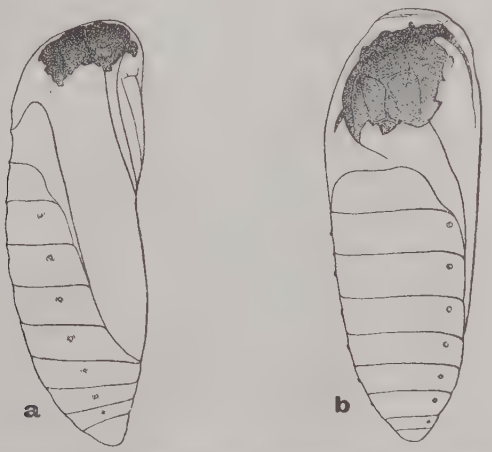

Fig. 1. Pupae of *Holcocera pulverea* after parasitism, *a*, by *Eurytoma pallidiscapus*, *b*, by *Chalcis tachardiae*.

this is partly due to *H. pulverea* being heavily parasitised. In the pupal stage this moth is attacked by the Chalcid, *Eurytoma pallidiscapus*, Cam. Imms & Chatterjee mention that only four examples of this parasite were reared by them during the entire course of their study, indicating its rare association with North Indian species of lac insects. In Mysore it is far from being scarce, which has enabled its life-history to be traced as a pupal parasite of *H. pulverea*. Fig. 1, *a*, shows a pupa of this moth from which a female, *Eurytoma pallidiscapus*, was reared on 14th November 1922.

Imms & Chatterjee state‡ that *Chalcis tachardiae*, Cam., may be a parasite of either *E. amabilis* or *H. pulverea*, and further that they could breed this Chalcid only in small numbers. In Mysore this insect is so scarce that for practical purposes

* Agr. Res. Inst., Pusa, Bull. 142, 1923, p. 67.
† Indian Forest Memoirs, iii, pt. 1, 1915, p. 31.
‡ Ibid, p. 34.

it may be considered as absent. It thus appears that *Chalcis tachardiae* in North India takes the place of *Eurytoma pallidiscapus* as a pupal parasite of *H. pulverea*. Fig. 1, *b*, shows a pupa of this moth from which a female *Chalcis tachardiae* was reared on 18th December 1922, the specimen being derived from lac grown on *Schleichera trijuga* at Bagra, near Sohagpur, Hoshangabad District.

My thanks are due to Dr. L. Coleman, Director of Agriculture in Mysore, for facilities for working in the laboratory under his charge and for his kind interest in my work.

FURTHER NOTES ON *ALYSIA MANDUCATOR* AND OTHER PARASITES (HYM.) OF MUSCOID FLIES.

By J. G. Myers, Sc.D.,
Imperial Bureau of Entomology.

Introduction.

During the summers of 1927 and 1928, the rearing of the Braconid, *Alysia manducator*, Panz. (Bull. Ent. Res., xvii, pp. 219-229) for shipment to Australasia as a measure against the sheep-maggot, was continued on a large scale at the laboratory of the Imperial Bureau of Entomology, Farnham Royal, Bucks. In addition a study was made of the Anthomyiid, *Hydrotaea dentipes*, Fabr., as a possible natural enemy for the buffalo-fly, *Lyperosia exigua*, de Meij., which has become a serious pest of cattle and buffalos in Northern Australia. Owing to the cold and wet conditions prevailing in 1927, the results were very irregular; but certain general facts regarding the complex of necrophagous maggots, predacious maggots and their respective parasites, gathered during this work, seem worth recording.

A vigorous effort was made to standardise the cultures, and dead cats were almost exclusively employed both for *Hydrotaea* and *Lucilia*; but the weather in 1927 led to exceedingly irregular results in all the outdoor cultures. When a bait was exposed it often happened that rain and cold delayed the visits of *Lucilia* and of *Calliphora* until the carcase was becoming too stale for their taste. Then either of two things happened—*Hydrotaea dentipes*, which oviposits in older meat than *Lucilia* and *Calliphora*, obtained a start, and its predatory maggots cleared out all the Muscoid larvae; or the carcase was exploited almost solely by such forms as *Muscina stabulans*, Fall., *M. pabulorum*, Fall., *Ophyra anthrax*, Mg., and *Piophila nigriceps*, Mg., all of which are attracted by advanced decomposition. In the former case we were sometimes left with practically pure cultures of *Hydrotaea dentipes*. The succession of insects in a decaying carcase is very definite, but is subject to the influence of a large number of meteorological, physical, chemical and biological factors, which it is not possible to analyse at the present stage of the investigation, without the aid of numerous and well-controlled experiments directed towards that end. Even within the single genus *Lucilia* there is a strongly-marked difference in preference for bait of different ages.

A few numerical examples will show that this is the case with *L. sericata*, Mg., which prefers staler bait, and *L. illustris* and *L. caesar*, which are attracted to the very freshest carcases and which form the bulk of the green swarms on freshly-killed animals. Fresh cats (*i.e.*, killed not more than two days previously) were exposed in open tanks and the following counts made: 12th July, 13 *Lucilia* in one net-sweep, 12 *L. caesar* or *L. illustris*, Mg. (♀♀ not distinguishable), 1 *L. sericata*; on a fresh rat's head, of 146 *Lucilia* entrapped, 91 were ♀ *illustris* or *caesar*, 40 *caesar* ♂, 6 *illustris* ♂, 5 *silvarum*, Mg., 1 *richardsi*, Coll., and 3 *sericata*. In the insectary one to two yards away, a number of cats, mostly at a very advanced stage of decomposition, were exposed on trays, and numbers of *Lucilia* were attracted to the outside gauze. Of these the following counts were made: 29th June, 15 *Lucilia*, of which 11 were *sericata*; 2nd July, 11 *Lucilia*, 10 *sericata*; 3rd July, 10 *Lucilia*, 9 *sericata*; 5th July, 19 *Lucilia*, 14 *sericata*; 7th July, 8 *Lucilia*, all *sericata*; 9th July, 46 *Lucilia*, 43 *sericata*; 12th July, 11 *Lucilia*, all *sericata*. Throughout July the vast majority of the flies on this gauze were *Phormia caerulea*, R.-D., *Lucilia sericata* and *Musca domestica*, while on the adjacent fresh cats there were swarms of *L. caesar* and *L. illustris*. This difference was maintained even when the gauze was as strongly sunlit as the open tanks. Fresh cats were, of course, introduced from time to time into the

insectary, but it may be presumed that their odour was mingled with and swamped by that of the more decayed carcases. *Alysia manducator* was attracted plentifully to the fresh cats, but practically not at all to the gauze of the insectary.

Alysia manducator, Panz.

In 1927, it was concluded, largely from the literature, that the host-preferences of *Alysia manducator* are taxonomically somewhat diverse. At the same time it was shown that ecologically they are very considerably restricted. Later observations have shown even more restriction in both directions. In England, in spite of all records to the contrary, *Alysia manducator* seems to be very largely confined to *Calliphora erythrocephala* and *Lucilia* spp. Nevertheless it is true that in Western Australia Newman has secured parasitism in *Chrysomyia albiceps* (*rufifacies*), and in New Zealand Miller has been successful with the same species and with *Calliphora stygia*, Fabr., in addition to the common English hosts. As indicating the tremendous rôle which olfaction plays in oviposition it may be mentioned here that when I visited him in Western Australia in 1927, Mr. L. J. Newman had had no success in parasitising *C. albiceps* with *Alysia*. In discussing his technique we found that he had, not unreasonably, since the work was done in his office, washed the maggots thoroughly before presenting them to *Alysia*. When he gave this up, parasitisation took place with no further trouble.

In a previous paper (1927, p. 221) I instanced a case in which a female *Alysia* oviposited in 58 *Calliphora* maggots, but avoided 13 of another, tougher species which were mixed with them. These rejected maggots, which were preserved, have since been determined as those of *Hydrotaea dentipes*.

In the same paper (pp. 220, 221) *Calliphora* was mentioned as a host of *Alysia manducator*. In most cases it was not ascertained whether *C. erythrocephala* or *C. vomitoria* was the host in question. There is now considerable evidence that *Alysia* will parasitise the former but not the latter. A dead cat, exposed on 27th September 1927, yielded practically a pure culture of *Calliphora* maggots, to the number of some thousands (Crop 20). Of the puparia 138 were dissected and showed no sign of parasitism. There was nearly a 100 per cent. emergence in the spring and all were *C. vomitoria*. Yet *Alysia* was active at the time this bait was exposed. Crop 21, from a cat laid out on 4th October, yielded similar results. Some 130 puparia were dissected without finding a trace of parasitism, and among the thousands of *C. vomitoria* which emerged in spring only one specimen of *C. erythrocephala* was found. Crop 22, however, from a cat exposed also on 4th October produced a mixed lot of *Lucilia* sp., and *Calliphora vomitoria*, of which the former were parasitised by *Alysia* at the rate of nearly 100 per cent., while the latter went entirely free. The absence of parasitism in maggots feeding on visceral offal, as mentioned in my earlier paper, may have been due to their being *C. vomitoria*. Unfortunately this was not ascertained, though the vast majority of these maggots were certainly *Calliphora*.

Now Wardle (Jl. Hyg., xxvi, pp. 445–464, 1927), in an interesting paper on the seasonal frequency of Calliphorine blowflies in Great Britain, has shown that *C. vomitoria* is much more attracted than *C. erythrocephala*, and both more than *Lucilia* spp., to baits exposed in the shade. In 1921 (Ann. Appl. Biol., vii, pp. 1–9) he agreed with Herms that this was due to a difference in phototropism between *Lucilia* and *Calliphora* and between the two species of the latter. On further analysis, however, he believes that lessened attraction is brought about by superficial desiccation induced by weather conditions, and such desiccation is less rapid in shelter than in the open. He thinks that this lessened attraction is more marked in male than in female and in *C. vomitoria* than in *C. erythrocephala* owing to lesser powers of olfaction. According to Miss MacGill, the male has considerably fewer supposed olfactory pits on the antennae than the female, and *C. vomitoria* than *C. erythrocephala*.

I believe this explanation to be only superficially true, since it ignores (*a*) the facts of ecological succession in carrion, and (*b*) the special ecological requirements of the different fly species. At Farnham Royal carrion baits exposed in the open have generally attracted the following succession: *Lucilia* spp., *Calliphora erythrocephala* and *C. vomitoria* (omitting numerous other flies), though there was some variation according to the nature of the bait. It seems, therefore, more reasonable to suppose that each species is attracted by certain definite products of decomposition which appear more or less in a similar order, and that difference in attractive power is not a mere physically quantitative function but a chemically qualitative one. Wardle's theory may, however, be true to the extent that an exposed bait, drying-up rapidly, has its chemical changes accelerated or even cut short by purely physical conditions; so that it may be only for a short time, or in extreme cases never, attractive to *C. vomitoria*.

Were Wardle's explanation wholly valid, it would be expected that parasitism by *Alysia manducator* would be much greater in the sun than in the shade, since its preferred hosts, *Lucilia*, are the most attracted to exposed baits. Actually, however, as Graham-Smith showed in 1919 (Parasitol., xi, p. 377) exactly the reverse is the case, puparia from a sunny situation being parasitised 25 per cent. and those from a shaded bait 57 per cent. Obviously a more profound analysis is demanded.

The greatest obstacle to the establishment of *Alysia manducator* in Australia is undoubtedly the presence of *Mormoniella vitripennis* (*Nasonia brevicornis*), which is a very destructive superparasite on all puparia that it can reach without burrowing. Fortunately this Chalcidid is very restricted and patchy in its distribution and is by no means widespread in the country districts. Thus at Mildura, Vict., judging from a very large number of *Chrysomyia albiceps* which I reared in 1927, it is not yet present.

Atractodes gravidus, Grav.

This Ichneumonid appears to be a specific parasite of *Hydrotaea dentipes*. Mellor (Ann. Appl. Biol., vi, p. 66) has recorded *A. tenebricosus*, Grav., and *A. exilis*, Hal., from the same host, in cow-dung, but the latter habitat would seem to indicate that the specific determination of the *Hydrotaea* was incorrect.

Large numbers of *A. gravidus* were reared from *H. dentipes* and from no other species, though the outdoor cultures contained maggots of many different genera and species. The female engaged in oviposition, or searching for the host, is quick to take flight, in marked contrast to the slowness and absorbed behaviour of *Alysia manducator* in similar circumstances.

Puparia from which *Atractodes* has emerged are lined with a much more delicate silken cocoon than that which *Alysia* weaves, though it is still a complete envelope. The anterior end of the puparium is gnawed off completely, leaving an exceedingly jagged edge, whereas *Alysia* more often than not bites off a neater circular cap, which is left hanging by a silken hinge.

On 8th October 1926, another *Atractodes* was found wandering on the bait among a number of *Alysia manducator*, engaged with the full-fed *Lucilia* maggots. It was enclosed with six of these maggots in a small box with damp blotting-paper, which it at once sucked with avidity. It then encountered a maggot, and, its antennae quivering, attempted to oviposit. It usually tried to insert the ovipositor somewhere near the posterior end, frequently curving round to the lower surface. The larva was more or less straddled. More often than not the parasite was thrown off. The maggot, perhaps when its skin was actually pierced, changed its usual crawling for a frantic writhing, curling and uncurling, now this way and now that, so that the parasite, with ovipositor still inserted, was flung over and over, with its abdomen often strained backwards into a bow. In these contortions the *Atractodes* is helped

by its exceedingly thin petiole and by the snake-like flexibility and extensibility of the rest of the abdomen, of which the tip, beyond the ovipositor, is attenuated and apparently very sensitive.

The longest observed insertion of the ovipositor was seven seconds. Sometimes it was inserted for only two seconds, and more often the parasite was thrown off before the instrument had entered. After withdrawal of the ovipositor the maggot continued to squirm vigorously for a second or two and then resumed its crawling. There was no period of insensibility as in larvae stung by *Alysia*. It is possible that *Lucilia* was not the usual host, and that all the attempts I witnessed were failures. This is rendered more probable by the fact that none of the six produced either parasites or flies, though one pupated.

This *Atractodes* was first determined by Dr. C. Ferrière (who kindly identified also the other parasites in these notes) as a *male* of *A. gravidus*. He and Dr. Waterston examined it again, and found there was nothing like it in the British Museum, but that it seemed strictly intermediate between *A. gravidus* and *A. bicolor*, Grav.

Figites striolatus, Hart.

This small Cynipoid was bred in large numbers from the puparia of *Hydrotaea dentipes*. Oviposition took place in very young maggots. The ovipositing females crawled about the crevices of the carrion in the manner described by Graham-Smith (1919, p. 357) for a *Figites* sp., which may have been the same one. The wings are closely appressed to the back, and bent down apically to the curve of the abdomen.

The adult emerges from the puparium, which is unlined, by biting an irregular hole near the anterior end, somewhat at the side, leaving the tip untouched. Never more than one parasite was obtained from each puparium. The general average size of parasitised puparia is very considerably smaller than that of normal ones, indicating perhaps that the larva, oviposited in very young, pupates before it has reached its full size. Mellor (Ann. Appl. Biol., vi, p. 66, 1919) reared an undetermined Figitid from a puparium of *Hydrotaea dentipes*.

Mormoniella vitripennis, Walk.

The short-winged males often sit on the back of a female, head to head, the antennae vigorously palpating hers. The male is really engaged in assiduously licking the female's antennae, beginning always at the base and moving up with a quick movement, the female holding her antennae steady the while. When disturbed he suddenly and rapidly shuffles backward and slides off the end of her abdomen.

Copulation has been observed only in direct sunshine. The male clasps the posterior part of the female's abdomen, his antennae playing on its middle, and his abdomen curved downward, forward and finally slightly upward to meet the female genital opening. In one case observed, a second male was in the usual position on the thorax, licking the female's antennae. This position is much more frequent than copulation. A male has been observed to slip to the rear and copulate for a few seconds and then come forward again to resume the licking of the antennae.

An attempt to secure parasitism of *Lucilia* larvae by *Mormoniella* failed entirely. Several pairs were placed in a vial with full-fed maggots, but no interest was shown. Occasionally one of either sex, but more often a female, walked over or even along a maggot, but there was no attempt at oviposition. This helps to confirm the results of other workers who have found *Mormoniella* to be only a pupal parasite.

ON THE GROWTH OF THE HEAD IN THE LARVA OF *ANOPHELES MACULIPENNIS*, MEIG.

By Julia Mitrofanova,
Section of Malaria, Bacteriological Institute, Perm, Russia.

While measuring the separate parts of the head in larvae of *Anopheles maculipennis* in the summer of 1926, I observed that in the later stages of the development in each phase the posterior part of the head is in the form of a collar, the length of which increases up to the next moult, whereas the anterior part of the head remains unchanged.

According to all the principal text-books of entomology (see Berlese, etc.) only the soft parts of insect larvae are capable of growth, owing to their extensibility, whereas the chitinous parts of the skeleton are commonly supposed not to grow. Therefore the increase in length of the head of the larva of *Anopheles*, which is covered with a hard chitinous skull, attracted my attention, and I readily followed the suggestion of Prof. Beklemishev to undertake a detailed investigation of the subject.

My material consisted of about 500 larvae collected in the neighbourhood of Krasnufimsk and Chusovaya (Ural Province) in the summer of 1926 (fixed in 70° alcohol), as well as skins of larvae from certain experimental cultures. The data thus obtained were, moreover, verified by daily measurements of live larvae, which had hatched from eggs laid by a female *Anopheles maculipennis* in the laboratory in the spring of 1927.

The method of measuring was invariably the same ; the larva was laid on a slide on its ventral side with the head directed away from the examiner under a coverglass. The head was measured from the base of the clypeal hairs to the collar, if already present, the collar being measured separately. The measurements were taken by the aid of an ocular micrometer, ocular 10 and objective 3 (Reichert's microscope).

The head of *Anopheles maculipennis* when just hatched (fig. 1, *a* I) from the egg is transparent and covered with a thin delicate skin. Its posterior border merges into the neck, which is rather mobile and in living larvae is usually contracted ; in dead ones it is often stretched out and distinctly visible. A few hours later the head of the larva assumes a light yellow colour, becoming less transparent, and on its posterior margin adjoining the neck there appears a border which at first is like a narrow band slightly curving towards the sides and of a deeper colour than the rest of the head. The border arises owing to a progressive thickening of a part of the skin of the neck adjoining the occipital opening. For example, at 9 a.m. on the 30th May 1927, the heads of certain larvae were quite pale and transparent ; at 2 p.m. on the same day they were of a light yellow colour and had borders 0·3 divisions in depth. The border, deepening progressively, reaches a depth equal to 1 division of the ocular micrometer and represents the initial collar ; at its base it is delimited by a sharp dark outline. After the border has formed, the thickening process spreads farther over the adjoining region of the soft skin on the neck, and thus the collar is gradually developed.

This structure in the larva of the 1st phase (fig. 1, *b* I) resembles a high collar encircling the neck and narrows from the base to the apex, the former being 1 micrometer division broader than the apex. Along the median line dorsally it is interrupted by a suture, and there are hairs or other appendages.

After the collar has reached its maximum depth (7 divisions), the larva moults and passes into the 2nd phase. Directly after the moult the head again appears

pale and transparent, and the border around the occipital opening is still absent (fig. 1, *a* II). Subsequently the head turns light yellow, and the border gradually develops to a depth of 1 division. Fresh layers are continually added, and towards

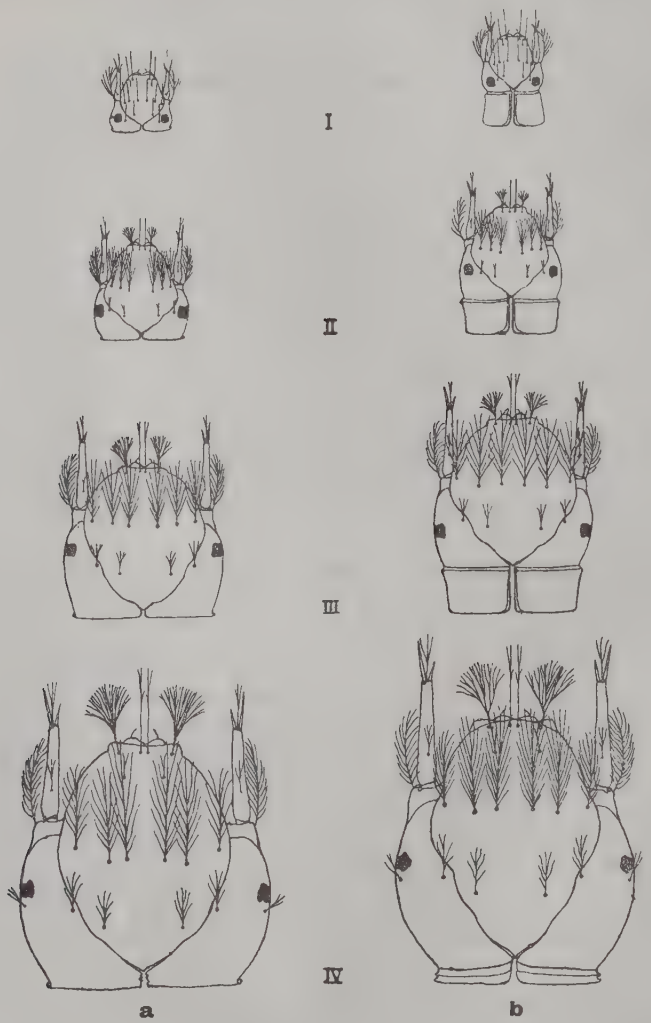

Fig. 1. *Anopheles maculipennis*, Meig., growth of head during the four larval phases : *a*, head at beginning, and *b*, at end of each phase.

the end of the 2nd phase the collar attains a depth of 7 divisions (fig. 1, *b* II), but the shape is cylindrical and parallel-sided. In this phase too the collar is darker than the rest of the head.

After this the larva again throws off its skin and passes to the 3rd phase (fig. 1, *a* III). Here, too, there is observed the same progressive growth of the collar as in

the preceding phase, but the collar reaches a greater depth (10 divisions) and narrows behind, being 1 division wider at the apex than at the base (fig. 1, *b* III).

Finally, in the 4th and last phase (fig. 1, *a* IV, and *b* IV) the border attains a size of 2 divisions, and the whole collar, with the border, in the larvae that we have measured, was equal to 5 div. at the most. Further, in this phase the collar has a second longitudinal suture, in the middle of its ventral surface (fig. 2, *b*). This suture sometimes fails to penetrate the border, which in some larvae remains continuous.

A comparison of the maximum length of the collar in the different phases show that it was equal (7 div.) in the 1st and 2nd phases, being largest in the 3rd (10 div.) and remaining comparatively short (5 div.) in the 4th. Thus the fact that the collar grows during the intervals between the moults was established by direct observation in culture.

In order to illustrate further the growth of the collar during each of the larval phases, a calculation was made of the correlation coefficients between the length of the collar and that of the body, which grows very rapidly during the intervals between the moults. For each of the four phases the calculation of the correlation coefficient was made separately. The data we obtained are given in the following table where *Z* represents the correlation coefficient and *Mz* the average error.

Phases.	*Z*	*Mz*
1 ...	0·83	±0·04
2 ...	0·72	±0·05
3 ...	0·87	±0·03
4 ...	0·50	±0·08

Thus there exists a close correlation between the length of the collar and that of the body, and though this is less in the 4th phase, it is still real and fairly considerable. The lower correlation in this phase may find an explanation in the variability of the length of the fully developed collar in larvae of this age ; from measurements of a number of larval skins we found it to vary from 2 to 5 divisions.

This growth of the collar appears to have remained unnoticed until now. Some authors have indeed figured and even described the collar in the larva of *Anopheles*. The most detailed description is given by Patton & Cragg (1913, p. 196) : " The posterior border [of the head] is slightly constricted and is encircled by a collar-like rim of pigmented chitin, continuous except at the middle line dorsally, where there is a slight interval. From this point a V-shaped suture passes forwards, the two arms diverging to extend to the inner base of the antenna." But apparently no authors have noticed the absence of a collar in the freshly moulted larva, its subsequent appearance, and its progressive growth during the whole period up to the next moult. It must be pointed out that Prof. L. La Face (Rome) has succeeded in establishing these facts independently of us, as we know from an oral communication that has not yet appeared in print.

The median suture on the ventral surface of the head of the larva of *Anopheles* in its 4th phase also has not been previously described. This suture (fig. 2 *b*) continues anteriorly almost as far as the base of the labium. Here it disappears after having undergone progressive attenuation, or else it terminates in a small bifurcation, and this occurs more often. This suture is very fine, slightly sinuous, and gives off several very fine and short lateral branches, not more than 1 division in length. The number and disposition of the lateral branches varies individually, but several branchelets are always present in the posterior part.

In the majority of 4th phase skins examined the medio-ventral suture was torn for half its length, but sometimes it remains entire and only stretches, its lumen

becoming somewhat broader, and before the border, where the groups of lateral branches are situated, there forms a star-shaped widening. The function of this suture is to make it easier for the pupa, with its large cephalothorax, to get rid of the larval skin. The larvae of the first three phases show no signs of this suture (fig. 2, *a*).

Is it interesting to note that the larvae of *Culex* and *Aëdes*, which have a much larger head that is likely to cause difficulties in moulting, are provided with a medio-ventral suture on the head not only in the 4th phase, as in *Anopheles*, but also in all the preceding ones. At the moult this suture splits almost to the base of the mental plate, and its edges usually diverge widely, as I was able to ascertain by examining skins of *Culex pipiens*, L., *Aëdes nemorosus*, Mg., *A. abfitchi*, Felt, and *A. sylvae*, Theo., while in the skins of the larvae of *Anopheles* the edges of the suture usually overlap one another.

In order to decide the question whether the actual head-capsule of the *Anopheles* larvae increases during the intervals between the moults, the heads of various larvae

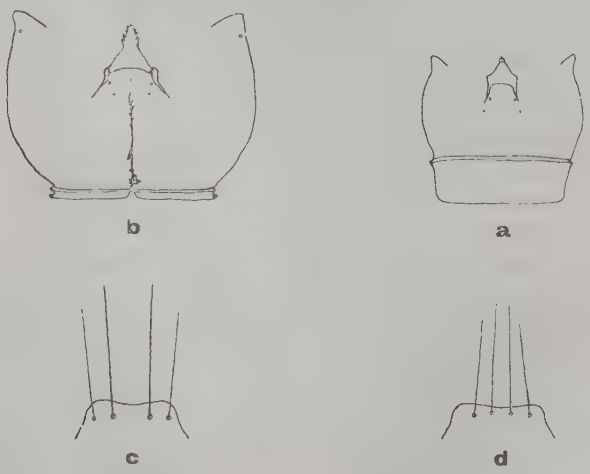

Fig. 2. *Anopheles maculipennis*, ventral view of head of larva of: *a*, phase III; *b*, phase IV. Clypeal chaetae of phase I of larvae of: *c*, *A. maculipennis*; *d*, *A. bifurcatus*.

were daily measured from the base of the median clypeal hairs to the anterior border of the collar. The data obtained by these measurements show that the head-capsule of the larvae remains unchanged the whole time between two moults, increasing only during the moult at the expense of the vanishing collar. The length of the head-capsule in the various phases was as follows: 1st phase 10 divisions, 2nd phase 20, 3rd phase 31–32, 4th phase 45–49.

At the moment of moulting there occurs an increase in the general length of the head; in the transition from one phase to another the length of the head-capsule of the larva that has moulted is not equal to the sum of the length of the capsule and the collar of the skin, but always somewhat exceeds it. Thus, for instance, a larva of the 2nd phase began throwing off its skin just at the moment when we were going to measure it; the head, which was measured directly after the moult, had a length of 32 divisions, while the sum of the lengths of the head and collar in the skin amounted to 25·5 divisions. Such an increase in the general length of the head during the moulting process occurred in all the measured larvae of *Anopheles maculipennis*,

as may be seen from the accompanying table, where $M+m$ is the average size of the head-capsule during the respective phase with the average error.

Phases.	$M+m$.	Length of the head + definite collar.	Increment during moult, ca.
1	9·98±0·05	16·98	2
2	18·96±0·14	26·96	5
3	31·59±0·23	41·59	10
4	52·37±0·23	57·37	

It was of interest to ascertain whether the antennae increased like the head during each phase, and daily measurements were taken for this purpose. It was always the right antenna which was measured (1) from the base of the antenna to the hair on it, and (2) from the hair to the free end. The total length of the antenna in each larva of the 1st phase was always 7 div. (1+6) ; in the 2nd phase it was 10 div. (2·5+7·5) ; in the 3rd phase 15 div. (4+11) ; in the 4th phase it averaged 22 div. (5+17), but the distal measurement varied from 16 to 18. In every case the length remained unchanged throughout the phase, increasing only during the moulting process.

Similar results emerged from the examination of some larvae of *Anopheles bifurcatus*, L., from the Ural Province. In some of the larvae, which apparently had recently moulted, the head was pale and transparent ; in other larvae there was already a narrow border of a darker colour (about 1 div. in depth) ; and finally in some a collar was also present. It was difficult to determine the greatest length of the collar in each separate phase, since the number of available larvae was but small.

One of the larvae of the 1st phase was captured in the act of moulting (it had not yet quite got rid of its skin). In the skin the length of the collar was 5 div., as compared with 7 div. in *A. maculipennis*. On the dorsal side of the collar the usual suture is also present, continuing into the V-shaped sutures of the head-capsule. As to the medio-ventral suture in the larvae of the 4th phase, it is also present and differs from that in *A. maculipennis* only in that (in the larvae at our disposal) it intersects the border also.

Thus the head, and especially the collar, of the larva of *A. bifurcatus* also grows during the period between the moults.

Some Differences in the Chaetotaxy of the Larvae of A. maculipennis *and* A. bifurcatus *due to Age.*

In the course of our measurements there became apparent some details in the morphology of *A. maculipennis* and *A. bifurcatus* which deserve special mention. In the designation of the chaetae we follow Martini (1923).

In all the measured larvae of *A. maculipennis* of the 1st phase, bred in the laboratory or collected in the field, the middle clypeal hairs (No. 2) are set very wide apart in comparison with the maturer larvae ; the distance between the middle clypeal hairs being equal to 2 divisions of the ocular micrometer and that of the angular clypeal hairs (No. 3) to 4 divisions throughout the whole phase (1 fig. 2, *c*). In the larvae of the 2nd phase the median clypeal hairs are drawn nearer together, their distance from each other being equal to 1 division, while the distance between the angular hairs (No. 3) remains the same, viz., 4 divisions. In the larvae of the 3rd phase the distance between the median clypeal hairs is 1 division (more frequently

1·5) and that between the angular ones 7 divisions. Finally, in the larvae of the 4th phase the distance between the median clypeal hairs is from 1·5 to 2 divisions, and 11–12 divisions between the angular ones.

Unlike *A. maculipennis*, the median clypeal hairs in the larvae of *A. bifurcatus* in the 1st phase are not so widely separated, the distance between them being one division during the whole phase and that between the angular clypeal hairs 3 divisions (fig. 2, *d*). The distance between the bases of the median and angular clypeal hairs in the 2nd, 3rd and 4th phases is the same in *A. bifurcatus* as in *A. maculipennis*.

Thus the larva of *A. bifurcatus* of the 1st phase may be distinguished from that of *A. maculipennis* (besides the character pointed out by Martini, *i.e.*, the difference in the shape of the hair No. 12 at the base of the antenna) by the distance between the clypeal hairs; in *A. bifurcatus* of the 1st phase they are situated nearly at an equal distance from each other, the median ones even somewhat closer to one another than to those at the angles. In the larvae of *A. maculipennis* of the 1st phase the median clypeal hairs are set widely apart, the distance between them being greater than that between the median and angular clypeal hairs.

Attention must also be drawn to the difference in the disposition of the frontal hairs (No. 5, 6 and 7, Martini) and the frontal clypeal hairs (8 and 9) during the different phases of the larval life of *A. maculipennis*. In the larvae of the 1st phase the frontal hairs No. 6 are situated farther backward by 0·5 divisions than those of No. 5, and the hairs No. 7 are 0·5 divisions still farther back, so that a line joining the hairs to the right and left would form a curve with its convex side directed forward. As to the frontal clypeal hairs, the hair No. 8 is 1 division farther forward than the hair No. 9, the convex side of the curve being directed also forward (fig. 1, I). In the larvae of the 2nd phase the hairs mentioned begin to assume the reverse position (fig. 1, II). The frontal hairs No. 6 are just a little nearer to the apex than the hairs No. 5, and the hairs No. 7 are one division nearer to it than No. 5. The convex side of the resulting curve is therefore now directed backwards. The hairs No. 8 are also located 1 division below the hairs No. 9. In the majority of the larvae of the 3rd phase (fig. 1, III) the frontal hairs No. 6 are located 1 division farther backwards than the frontal hairs No. 5 and 7, the latter being almost on the same level, but the frontal clypeal hairs No. 8 have become even more posterior than the hairs No. 9 (by 2 divisions). Finally, in the larvae of the 4th phase (fig. 1, IV) the hairs No. 5 and 6 are on the same line and the hairs No. 7 two divisions in front of them.

The distribution of the hairs remains without change throughout the phases, the displacement occurring during the moult.

In conclusion I express my deep gratitude to Prof. V. N. Beklemishev for his valuable advice and for the help he has given to my work.

AN IMPROVED METHOD OF MOUNTING MOSQUITO LARVAE.

By B. A. R. Gater,

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The identification of mosquito larvae, especially of the genus *Anopheles*, is now so common a practice in the Tropics that the need of a simpler method of mounting has been widely felt. Whereas in many instances a larva can be identified by examining it alive in a drop of water, in countries where many similar forms are met with mistakes are sometimes made. A great deal of identification work is done by Health Inspectors who have not the practice necessary for determining species while they are alive, and in Malaya, where some species cannot be separated by an examination of the anterior clypeal hairs alone, a quick method of mounting so that occipital hairs and other structures can be seen is required.

The methods usually recommended for mounting whole larvae are somewhat tiresome, and generally involve so much handling that, unless the operator is careful, hairs of taxonomic importance are broken off in the process. Where large numbers of mounts are required by members of the Health Branch for instruction, the balsam method has been found to be too long and complicated in the hands of partly trained assistants.

Howard, Dyar & Knab[1] recommend macerating in potash, dehydrating, clearing and mounting in Canada balsam; Giles[2] advocates Farrants' medium. MacGregor[3] recommends mounting in cells with his borax-formalin solution or in balsam. Strickland & Choudhury[4] have recently stated that they find clearing in phenol and clove oil and mounting in balsam to be the best method. The writer's usual practice was to mount in Euparal from 90 per cent. alcohol. None of these methods was considered to be entirely satisfactory, and a search for a simpler and better method was therefore made.

Mounting Medium recommended.

While working on mites the writer used the medium evolved by Berlese, as given by Bolles Lee[5] and recommended by Dr. A. D. Imms for small arthropods. This medium was tried on mosquito larvae, and although it was too fluid for making satisfactory permanent mounts, the results were so good that a number of modifications was made up. The formula which finally proved most successful was as follows:—

Water, distilled	10 per cent.
Gum arabic, picked	8 ,, ,,
Chloral hydrate	74 ,, ,,
Glucose syrup	5 ,, ,,
Acetic acid, glacial...	3 ,, ,,

The ingredients should be dissolved in the order named, preferably on a water-bath or in an oven at about 50° C. The fluid should be filtered by means of a Buchner funnel and suction pump, using a No. 5 Whatman paper. This takes some time, but small quantities can be clarified quickly in the centrifuge. Glucose syrup was made by dissolving 98 grm. bacteriological glucose in 100 ml. of water. The writer adds cocaine hydrochloride 0·3 per cent. and reduces the acetic acid to 2·7 per cent., but although rather more satisfactory mounts are obtained in this way, the cocaine is not essential and has the disadvantage that it can only be handled under supervision.

Method of Mounting.

A larva is picked out of its bowl with a large-bore pipette and placed on a slide. Surplus water is withdrawn, first with a fine-bore pipette and finally with blotting

paper. While this is being done the larva should be manoeuvred into the centre of the slide, an operation which requires a little practice if the specimen is very active. Some mounting medium is now carefully dropped on the larva, and after an interval of a minute a coverglass is lowered into place. Clearing begins as soon as the larva is dead.

For permanent mounts the preparation is put aside to dry, which takes about three weeks in the moist atmosphere of Malaya. Drying can be accelerated by gently warming the slide, but it must not be subjected to high temperatures. As soon as the preparations are dry externally they can be ringed. In this laboratory cellulose varnishes, either purchased or made from waste celluloid and amyl acetate, are used for closing the mounts, which are finished with one or two coats of asphaltum.

Since the volume of the mountant decreases considerably on drying, an excess should be used in the first instance. Cells have not been found essential, but can be used if necessary.

Results.

The rapidity with which clearing takes place varies according to species, but it is complete within two hours in the case of most Malayan *Anopheles*. Highly pigmented species such as *A. umbrosus* require longer, up to twenty-four hours.

The advantages claimed for this method are simplicity of technique and efficiency in clearing. The larva is only lifted on to the slide with a pipette and is not afterwards touched, while clearing is of such a degree that occipital hairs and in most cases the structure of the mentum can clearly be seen. An additional advantage is that in the majority of cases the mouth-brushes are withdrawn, and although they are generally extruded again some time later, an unobstructed view of the lateral anterior clypeal hairs, enabling them to be drawn with a camera-lucida, is obtained. All the hairs are complete and in their natural positions. As to the permanence of these mounts it might be mentioned that the first ones made, now a year old, show no deterioration.

Modified Method for Surveys.

Where permanent mounts are not required, and an identification only is desired, a simpler medium can be employed. This consists of water 37 per cent., chloral hydrate 57 per cent., acetic acid 6 per cent.

Larvae can either be placed in this fluid in the field, or they can be brought back to the laboratory and placed in the fluid on slides by an attendant. Identifications can rapidly be performed as soon as the larvae are cleared.

References.

(1) Howard, L. O., Dyar, H. G., & Knab, F. The Mosquitoes of North and Central America and the West Indies, i, p. 184, 1912.
(2) Giles, G. M. A Handbook of the Gnats or Mosquitoes, p. 34, 1902.
(3) MacGregor, M. E. Mosquito Surveys, p. 204, 1927.
(4) Strickland, C. & Choudhury, K. L. An Illustrated Key to the Identification of the Anopheline Larvae of India, Ceylon and Malaya, p. 16, 1927.
(5) Lee, A. Bolles. The Microtomists' Vade Mecum, p. 504, 1921.

SOME COCCIDAE COLLECTED BY DR. J. G. MYERS IN NEW ZEALAND.

By E. Ernest Green, F.E.S., F.Z.S.

In his recently published work, " A Classification of the Higher Groups and Genera of the Coccid Family Margarodidae " (U.S. Dept. Agr., Tech. Bull. no. 52, July 1928), Mr. H. Morrison has made some sweeping alterations in the previously accepted status of tribes and genera, some of which may possibly be open to criticism. But his classification is so vastly superior to anything hitherto attempted that—if only for the sake of uniformity—it should be adopted until a still better complete classification has been propounded. So far as it affects the matter dealt with in the following paper the only novelty is the erection of a new subfamily, Coelostomidiinae, with several new tribes and genera, to accommodate the species hitherto included in *Coelostomidia*, together with several allied genera.

Subfamily Coelostomidiinae.

Ultracoelostoma assimile (Mask.).

" On *Nothofagus* sp., Nelson, iii.1924." " Very thickly infesting bark of *Nothofagus*, Motueka, Nelson district, v.1924."

Together with this material was received some that was " said to be part of Maskell's duplicate material." Dr. Myers's material included both nymphs and adult females.

Coelostomidia pilosa (Mask.).

" On undetermined plant, Pokaka, 10.ii.1922 " (*D. Miller*).

Coelostomidia zealandica (Mask.).

Adult males and females, ovisacs, and nymphal tests. " On *Muehlenbeckia australis*, Wellington, x.1921."

Coelostomidia wairoensis (Mask.) (fig. 1).

Male puparia and adult males " from *Leptospermum ericoides*, North Auckland, 10.v.1923." Adult females " on ground beneath *Leptospermum* bushes, sand dunes, Kaitala, N. Auckland."

The latter were submitted as adult females of *wairoensis*, and I have no reason to doubt this determination. No other species has been recorded from *Leptospermum*, and these insects differ from any other known species of *Coelostomidia*. But the adult female of *wairoensis* has, apparently, never been described. The species was named from the male only, in describing which Maskell adds: " adult female, female of second stage, and larva unknown." Presuming that we now have the adult female, I append the following description.

Adult female ovoid, broadly rounded posteriorly; segmentation moderately defined, the junctions (in mounted preparations) indicated by an absence of dermal pores on the intersegmental tissue. Antenna (fig. 1, *c*) 9-jointed, all except 9th broader than long; very gradually tapering from the base to the rounded apex; 1st to 8th joints each with a distal ring of longish setae, the 3rd with some additional setae across the middle and the 9th with scattered setae. Legs (*a*) robust; all of about the same size; tarsus slightly more than half the length of the tibia, in the ratio of 15 to 28; claw falcate, rather slender. Mouth-parts undeveloped. Thoracic spiracles normal. Abdominal spiracles (*d*), seven on each side; viewed vertically (*e*), each spiracle is seen to have a circular rim (with a diameter of 0·175 mm.) within which is a sharply defined trilobate aperture; without pores in the atrium. Rectal

tube (in my examples) rather indefinite; but with a well marked chitinous ring at some distance from the orifice. Dermal setae (*b*) numerous, each mounted on a prominent conical or rounded tubercle; mostly small, but with a few scattered macrosetae which have a narrow basal collar. Dermal pores (*b*) circular, very obscurely bi- or tri-locular. Length 4·25 to 4·5 mm.; breadth 2·5 mm.

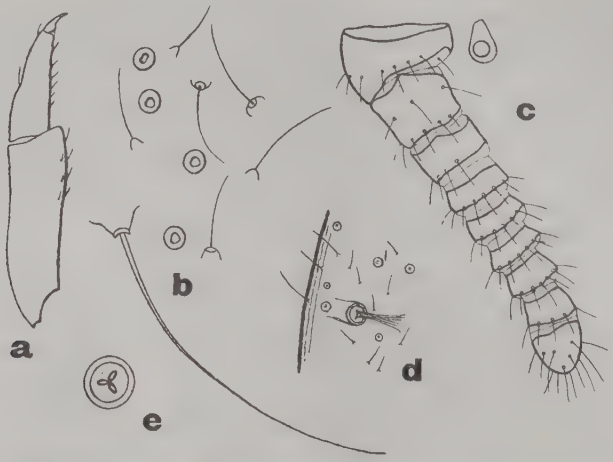

Fig. 1. *Coelostomidia wairoensis*, Mask., adult ♀: *a*, tibia and tarsus of 1st leg, ×80; *b*, pores and setae from frontal area, ×450; *c*, antenna and eye, ×80; *d*, abdominal spiracle, lateral view, ×220, and *e*, vertical view, ×450.

Coelostomidia montana, sp. n. (figs. 2, 3).

Female nymphs occupying cavities in a mass of white wax of a soft and pulverulent character. Isolated cells are of a depressed spherical or broadly oval form and have a firmer outer crust. Insect (fig. 2, *a*) very broadly ovoid; not conspicuously segmented. Antenna (*b*) 8-jointed, broad, short, tapering; the terminal joint hemispherical, with about 10 short stout setae; the remaining joints narrowly annular, each with 1 or 2 short setae on the inner side. Limbs (*c*) rudimentary, short and stout, but with the full complement of segments—coxa, femur, tibia, tarsus and claw. Mouth-parts large and conspicuous. With two pairs of thoracic and seven pairs of smaller, funnel-shaped, abdominal spiracles (*g*), the latter each with a ring of 8 conspicuous pores in the atrium. Rectal tube (*f*) constricted and invaginated at a point slightly beyond the middle: the outer half encircled by a ring of quinquelocular pores, the inner half with a zone of polygonal cells. Posterior extremity of the body with scattered, stout, flask-shaped spines (*d*). Derm with irregular transverse series of small callosities and crowded with conspicuous pores of two kinds (*e*), *viz.*, numerous micropores, which may be either 2–, 3–, 4–, or 5-locular, distributed over both dorsum and venter, and large discoid pores, varying in diameter, with granular centres, very sparsely distributed over the venter, more particularly across the basal segments of the abdomen. Length, 3 mm. Breadth, 2·5 mm.

Adult female (fig. 3, *a*) ovoid, depressed, inconspicuously segmented. Antenna (*e*) 10-jointed, elongate, cylindrical; 1st and 2nd joints largest, 3rd to 9th annular, the 10th hemispherical; the terminal joint with about 10 longish setae, the remainder each with a ring of setae on its distal edge. Eyes small but prominent. Mouth-parts rudimentary, consisting of indefinite indications of a tentorium and a small triangular labium surmounted by a few short setae. The limbs, in the single example, are all missing, with the exception of the coxae and one femur, the size of which indicates

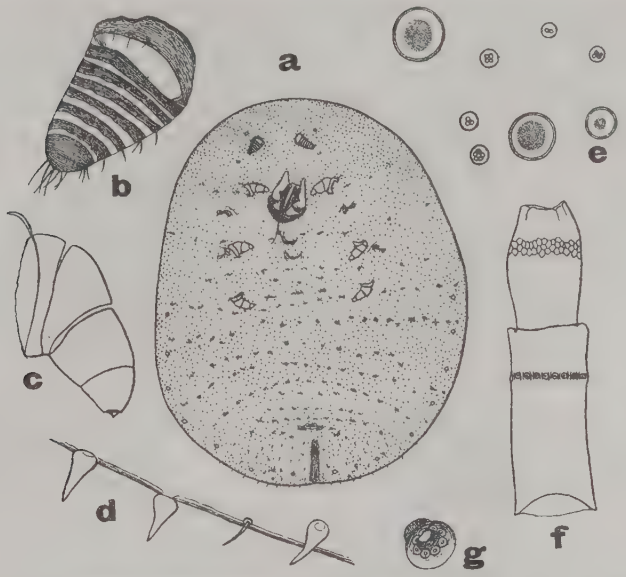

Fig. 2. *Coelostomidia montana*, sp. n.: *a*, nymph of ♀, ×18; *b*, antenna, ×135; *c*, 1st limb, ×135; *d*, dermal spines, posterior extremity, ×450; *e*, pores from venter of abdomen, ×450; *f*, anal orifice and rectal tube, ×130; *g*, abdominal spiracle, ×280.

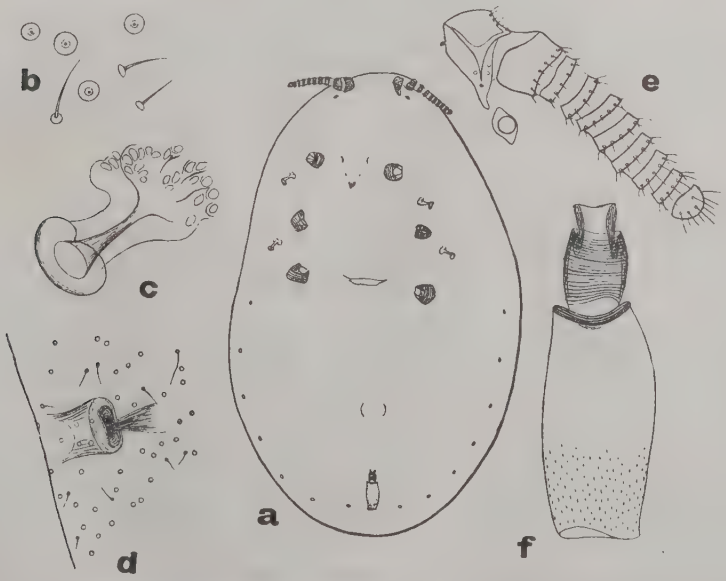

Fig. 3. *Coelostomidia montana*, sp. n.: *a*, adult ♀ (legs omitted), ×18; *b*, dermal pores and setae, from frons, ×450; *c*, thoracic spiracle, ×220; *d*, abdominal spiracle, ×220; *e*, antenna and eye, ×80; *f*, anal orifice and rectal tube, ×130.

that they were well developed. Thoracic spiracles (*c*) of the usual form. Abdominal spiracles (*d*) smaller, seven on each side ; diameter 0·04 mm. ; without pores in the atrium. Rectal tube (*f*) sharply constricted and invaginated at two points beyond the middle ; without zones of cells or pores ; the posterior quarter with numerous small thickened striae. Derm of both dorsum and venter with numerous small circular pores and short trichiform setae (*b*), intermingled with scattered macrosetae. Length, 3·5 mm. ; breadth, 2·5 mm.

Under loose bark of *Dracophyllum traversii*, Arthur's Pass, 3,300 ft., i.1923.

The habitat and character of the nymphal cysts resemble those of *C. compressa*, Mask. (as described and figured in N.Z. Trans., xxiv, p. 46, Pl. xi, figs. 5, 6, 1891), but the insects are quite dissimilar. The nymph of *compressa* is said to have the antennae " reduced to a single small joint," and " feet entirely absent." Maskell's description of the adult female of *compressa* is inadequate for comparison, but I gather (from his figures) that the terminal joints of the antennae are conspicuously enlarged, in which particular it differs markedly from *montana*.

The nymph of *montana* more nearly resembles that of *zeylandica*, but shows marked differences in the characters of the abdominal spiracles which (in *montana*) contain a single ring of pores in the atrium, whereas the spiracles of *zeylandica* contain a broad zone of pores. Moreover, Maskell's species undergoes the nymphal stage within " a thick, hard solid test of yellow wax," fully exposed on the twigs of the host-plant.

Very near *C. wairoensis*, from the adult female of which it differs in having 10 (instead of 9) joints in the antennae ; and in the very much larger abdominal spiracles (*cf.* fig. 3, *e* with 1, *c*, and fig. 3, *d* with 1, *d*). The nymph of *wairoensis* is not known.

Subfamily Ortheziinae.

The only representative of this group in Dr. Myers's collection proves to be an undescribed species of *Newsteadia*. This is of particular interest as Morrison, in his recent review of the Ortheziinae (J. Agr. Res., xxx, p. 97, 1925), propounds good reasons for supposing that the subfamily " is predominently American . . . both in origin and development." I am pleased to name this interesting species after its discoverer.

Newsteadia myersi, sp. n. (fig. 4).

Adult female superficially resembling *floccosa*, but with the waxy dorsal lamellae shorter, more compact and denser. Limbs pale brownish ochreous. Derm entirely membranous, without any chitinous plates. Of the four examples available for study, one has lost both antennae, two others have each lost one of the pair, the fourth only having both antennae intact. In this example one of the antennae is 5-jointed, while the other has 4 joints only (fig. 4, *j*). The single antenna in one of the other examples possesses 6 distinct joints (*i*), while that of the fourth example is again 4-jointed. In the four antennae present we have, therefore, two with 4 joints, one with 5 joints and one with 6 ; but it is probable that this last is the normal number, the lower numbers resulting from a fusion of one or more joints. The apical joint is unusually long, being more than one-third the total length of the antenna. It is transversely rugose ; with a longish stout seta at the extremity, a shorter (sometimes claviform) seta at about one-fifth from the extremity, and one or more small spiniform setae. The second joint has an incomplete transverse crease across the middle, a conspicuous circular sensory pore on the apical half, and three or four small spiniform setae. The remaining joints each bear one or two similar setae. Eyes

rounded and prominent, but so weakly chitinized that they are difficult to detect in a mounted preparation. Labium (*d*) relatively short and broad, its total length only slightly more than its breadth at the base; its apex evenly rounded. Legs (*a*) moderately large; without any tibio-tarsal articulation or any demarcation of the trochanter; with scattered, small, spiniform setae. Thoracic spiracles rather small and weakly chitinized. I have been unable to detect any abdominal spiracles, though Morrison gives 5 pairs as the number normal to the genus. Derm with spinous tracts corresponding with the areas occupied by the waxy lamellae; the spines bulbous at base and tapering to a blunt point. Venter with a broad and crowded band of spines (the ovisac band) across the base of the abdomen and continued along each side almost to the posterior extremity; the spines of the hinder margin of this band (*f*) very closely set and more sharply pointed than those on the other ceriferous tracts.

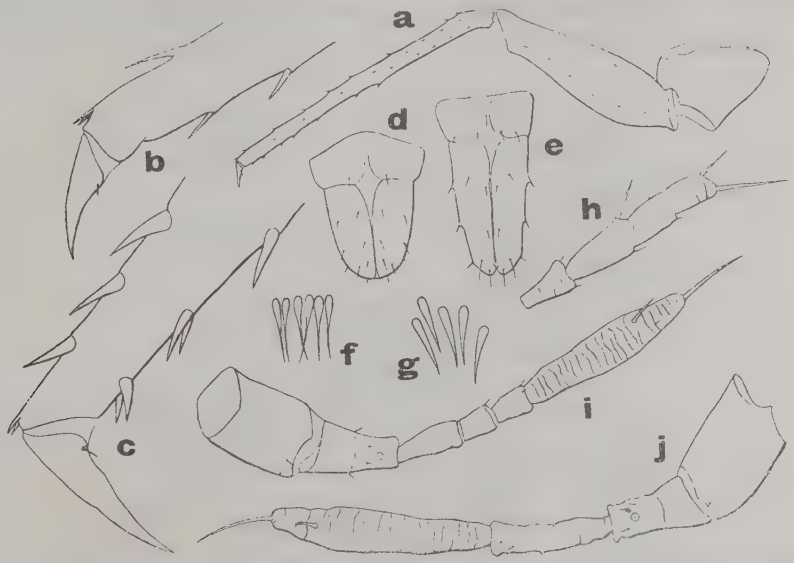

Fig. 4. *Newsteadia myersi*, sp. n.: *a*, 3rd leg, ×80; *b*, 3rd leg, foot, ×450; *d*, labium, ×130; *f*, spines from posterior border of ventral band, ×450; *i*, antenna, 6-jointed, ×130; *j*, antenna, 4-jointed, ×130. *Newsteadia floccosa*, DeG.: *c*, 3rd leg, foot, ×450; *e*, labium, ×130; *g*, spines from posterior border of ventral band, ×450; *h*, terminal joints of antenna, ×130.

The spaces between the spinous tracts with a few slender setae, more crowded across the genital area. Anal ring broad, closely clustered with pores; with 6 stout, moderately long setae. Total length of body (without appendages), 1·12 to 1·25 mm.

Amongst leaf mould, Ohakuna, 13.i.1924 (*J. G. Myers*).

Although the few examples available for study do not display any ovisacs, the presence of the "ovisac band" shows that they are sexually adult.

N. myersi may be distinguished from *floccosa* by the relatively short labium (*cf. d* and *e*), and by the less strongly spinose limbs and antennae (*cf. b* with *c* and *i* with *h*).

Subfamily Pseudococcinae.

"Mealy-bugs" are very poorly represented in the collection, by two specimens only, belonging to two distinct (and apparently undescribed) species.

Pseudococcus viticis, sp. n. (fig. 5).

Adult female ovate. Length, 3·75 mm. Breadth, across middle, 2 mm. Antennae missing, probably 8-jointed. Labium longer than broad, acutely pointed, distinctly dimerous. Rostral loop about four times the length of the labium, extending to the level of the 2nd pair of legs. Limbs large and robust ; tarsus of 3rd leg (fig. 5, *a*) approximately one-third the length of the tibia, which has numerous conspicuous translucent pores—extending almost to the base, but more crowded towards the distal extremity ; coxa without conspicuous pores ; claw without denticle. Cerarii situated submarginally ; 13 on each side ; those on the terminal and penultimate segments (*g, f*) large, conspicuous and with a sharply defined circular outline, each with 6 or 7 longish, stout, acute spines and densely crowded with micropores ; the frontal cerarii (*b*) with 4 similar but shorter spines, crowded with micropores, but not sharply circumscribed ; the remainder (*c, d, e*) inconspicuous, with

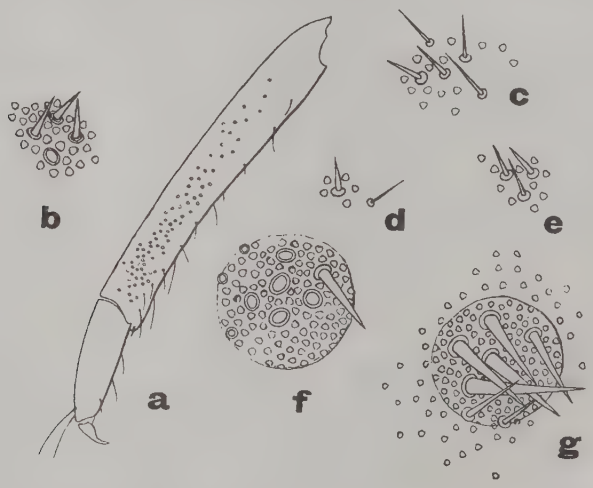

Fig. 5. *Pseudococcus viticis*, sp. n. : *a*, 3rd leg, ×130 ; *b*, frontal cerarius ; *c, d, e*, 4th, 6th and 10th cerarii ; *f, g*, penultimate and terminal cerarii, ×450.

small, slender spines and loose clusters of micropores. In the single example under observation the numbers of the cerarial spines are as follows : (1st) 4, (2nd) 2–3, (3rd) 2, (4th) 4–5, (5th) 2–3, (6th) 2–3, (7th) 3, (8th) 3, (9th) 3, (10th) 3, (11th) 3, (12th) 6–7, (13th) 7. Body setae small and inconspicuous, except on the frontal area. Micropores, of the usual subtriangular type, evenly distributed over the derm. Dorsal ostioles not noticeable. A single large, irregularly oblate, medio-ventral ostiole.

On *Vitex lucens*, Whangaroa, 2.xii.1923 (*J. G. Myers*).

I know of no other species that has been recorded from this host-plant. The limbs and cerarii have such distinctive characters that I have ventured to described this new species from a single available example.

? *Pseudococcus* sp.

A single example, " On *Podocarpus dacrydioides*, Ruakura, iii.1924 (*D. Miller*)," has unfortunately lost the antennae and all its limbs. It has some peculiar characters, more particularly in the presence of 5 large circular pores on each side of the body

(1 pair on frons, 1 on mesothorax, 1 on metathorax and 2 on the abdomen). Each pore is surrounded by a denser chitinous area and associated with a short, stout, tubular duct. There are no definite cerarii, except on the par-anal lobes, where there are two or three stout spines. No species of *Pseudococcus* has been recorded from *Podocarpus*.

Subfamily ERIOCOCCINAE.

Eriococcus coriaceus, Mask.

On *Eucalyptus globulus*, Christchurch, 1.xii.1920.

I note that the female insect gives out a purplish stain when boiled in potash. Maskell, in his original description of the species (N.Z. Trans., xxv, p. 229), states that "it is viviparous, and several specimens were so full of lively larvae that it seemed a wonder how these could find room." In the material submitted by Dr. Myers, the sacs were packed with unhatched ova.

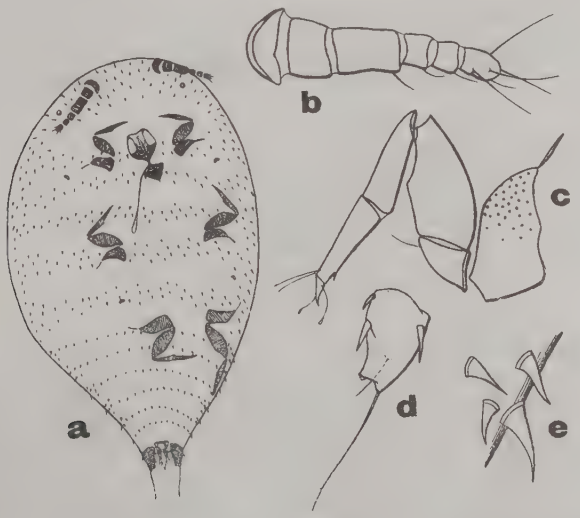

Fig. 6. *Eriococcus sophorae*, sp. n.: *a*, adult ♀, opt. sect., ×50; *b*, antenna, ×220; *c*, 3rd leg, ×220; *d*, par-anal lobe, ×220; *e*, spines from margin of abdominal segment, ×450.

Eriococcus sophorae, sp. n. (fig. 6).

Sac of female ochreous; ovate, strongly convex; with a more or less conspicuous medio-longitudinal rounded carina on the posterior half; with numerous erect glassy filaments. Length, 1·75 mm.; breadth, 1 mm.

Adult female (fig. 6, *a*) ovate, narrowing posteriorly. Antenna (*b*) 6-jointed, the 3rd longest. Labium short, triangular; its length equalling the breadth at base. Legs (*c*) robust; the tarsus as long as or slightly longer than the tibia; claw with a minute (almost imperceptible) denticle near the apex; coxa of 3rd pair with conspicuous translucent pores on the outer half. Par-anal lobes (*a*, *d*) prominent, heavily chitinized; the extremity truncate or slightly concave; with a longish stout spine on the outer side and two spines on the inner side; with a very short, tooth-like spine at the inner angle of the truncate extremity and a longish seta on the ventral

side. Caudal setae longer than the par-anal lobes. Anal ring with 6 longish stout setae. Dorsal spines (*e*) acute, curved, broad at base and tapering to a sharp point, in crowded transverse series across the thorax (each series widening laterally) and in single series across the abdomen, those on the margin slightly larger. Some short setae sparsely distributed over the venter. Body pores few, small and very inconspicuous. Length, averaging 1·25 mm.

On *Sophora tetraptera*, Dunedin, i.1921.

Other examples, on *Aristotelia racemosa*, Pokaka, 10.ii.1922, differ from the type in the more fulvous colour of the sac, against which the paler carina stands out in sharp contrast. The antennae, in this form, have an indistinct septum across the middle of the 3rd joint ; the spines are of the same form, but are rather larger, though less numerous.

The form of the sac is strongly suggestive of that of *E. tricarinatus*, Full., but the dermal spines—in that species—are larger and do not taper to a sharp point.

Gossyparia cavellii, Mask.

On *Nothofagus solandri*, Christchurch, 1.xi.1921.

Although the limbs and dermal spines are smaller than those of examples ex coll. W. M. Maskell and G. Brittin, I do not feel justified in separating the two forms.

Subfamily Asterolecaniinae.

Asterolecanium variolosum, Ratz.

On *Quercus robur*, Christchurch, 14.viii.1921.

This is the species recorded by Maskell as *quercicola*, Bouché ; but that name is now recognised as a synonym of *variolosum*.

Subfamily Lecaniinae.

Lecanium persicae (Fabr.).

On grape vine, Whangarei, 8.ii.1923.

There has, for some time, been considerable confusion amongst recent writers (including Douglas, Newstead and myself) in the nomenclature of our commoner British species of *Lecanium*. I am now convinced that Marchal (" Note sur les Cochenilles de l'Europe," Ann. Soc. Ent. Fr., lxxvii, 1908) was correct in his interpretation of these species. He has shown that the species referred by British and some other authors to *persicae* is actually referable to *corni* of Bouché. The true *persicae* of Fabricius is the equivalent of *berberidis*, Schr., and is readily recognisable by the submarginal series of conspicuous tubular gland-pores. It is a minor pest of the grape vine in the Mediterranean region, but does not occur in the British Isles. It was correctly recorded (as *berberidis*) by Maskell, on vines in Australia, and—more recently—by Hall, on mulberry trees in Egypt.

Lecanium (*Saissetia*) *hemisphaericum*, Targ.

On *Platycerium alcicorne*, Auckland, 19.viii.1921.

Lecanium (*Saissetia*) *oleae* (Bern.).

On ?, Ruakura, 27.vii.1921 (*D. Miller*).

Lecanium (*Saissetia*) *nigrum*, Nietn.

On *Asparagus* sp., Invercargill, 5.v.1922.

Ctenochiton piperis, Mask.

On *Macropiper excelsum* and *Coprosma robusta*, Kohukohu, N. Auckland, 17.xlii.923.

Ctenochiton viridis, Mask.

On *Hedycarpa arborea*, Korokoro, Wellington, i.1921.

Ctenochiton perforatus, Mask.

On *Pittosporum eugenioides*, Hutt, Wellington, i.1920.

Ctenochiton sp. (possibly *fuscus*, Mask.).

On *Rhopalostylis sapida*, Pakaraka, N. Auckland, 21.xii.1923. The material (consisting of a single parasitised female) is insufficient for determination.

Inglisia leptospermi, Mask.

On *Leptospermum ericoides*, Governor's Bay, 30.iv.1922.

Inglisia patella, Mask.

On *Pittosporum* sp., Christchurch, 13.viii.1921.

Subfamily Diaspinae.

Aspidiotus (*Hemiberlesia*) *camelliae*, Sign.

On *Elaeagnus japonica*, Auckland, 19.viii.1921; and on *Hoheria* sp., Te Paki, N. Auckland, 12.xii.1928.

Aspidiotus hederae, Vallot.

On *Meryta*, York Bay, Wellington, and on a palm, Invercargill, 5.v.1922.

Aspidiotus (*Chrysomphalus*) *aurantii*, Mask.

On *Citrus limonum*, Auckland, 19.viii.1921.

Aspidiotus (*Chrysomphalus*) *rossi*, Mask.

On *Euonymus japonicus*, Hastings, 19.viii.1921.

Lepidosaphes eucalypti, Frogg.

On *Eucalyptus globulus*, Governor's Bay, 1922.

Lepidosaphes cordylinidis, Mask.

On *Cordyline australis*, Christchurch, 13.viii.1921.

Lepidosaphes asteliae, sp. n. (fig. 7).

Puparium of female elongate, more or less dilated behind, of rather irregular outline, flattish; very pale stramineous, almost colourless, translucent; exuviae of the same tint. Length, averaging 2 mm. Male puparium similar, but much smaller.

Adult female of normal form, rather stout; abdominal segments moderately protuberant; posterior extremity tapering to a blunt point. Vestigial antennae with a single, longish, stout, curved bristle. Anterior spiracles with a small and very inconspicuous group of 4 or 5 parastigmatic pores. Pygidium (fig. 7, *a*) with five loose groups of perivulvar pores, both upper and lower groups often broken up into two or more separate clusters; median group with from 3 to 5 pores, upper laterals with from 3 to 13 (average 9), lower laterals with from 9 to 14 (average 12); anal orifice conspicuous, central; posterior margin with the median trullae large, prominent and broadly conical, their bases confluent; with a single, small, dentiform lateral trulla on each side; squamulae of the spiniform type normal to the genus; marginal setae rather long, acicular; ovate dorsal pores on margin only, none on disc, but with a short series of 2 or 3 on each side at the base of the pygidium. Length, averaging 0·75 mm.

On *Astelia solandri*, York Bay, Wellington (*J. G. Myers*); also on *Astelia* sp., Buck Bay, Nelson (*G. Brittin*). Associated, in both cases, with *Fiorinia myersi* (described below).

Fig. 7. *Lepidosaphes asteliae*, sp. n.: *a*, pygidium of adult ♀ (ex coll. Myers); *b*, median trullae of ♀ (ex coll. Brittin); ×450.

In the examples received from Mr. Brittin, the median trullae (*b*) exhibit a slight excision on their outer margins and the fusion of the pair is not quite so complete.

Maskell described a *Lepidosaphes epiphytidis* from *Astelia*; but he figures the median trullae of his species as being separated by an appreciable gap, whereas in *asteliae* they are firmly fused together. Moreover, the male puparia of *epiphytidis* are described as being very dark brown or black.

Lepidosaphes ulmi var. **novozealandica,** n. (fig. 8).

Pygidium of adult female (*a*) with median trullae relatively smaller and lateral trullae relatively larger than in typical *ulmi*. The median trullae show no indication of a trilobate condition, except in the early adult stage, when they may be obscurely tricuspid. But the principal distinction between var. *novozealandica* and typical *ulmi* is in the arrangement of the smaller dorsal pores, which in the variety are scattered more or less irregularly over the median area of the pygidium, while in *ulmi* they are concentrated into two longitudinal series (cf. *a* with *b*). The perivulvar pores, which (to avoid confusion) I have not indicated in the figures, are disposed in the usual five groups, averaging 7, 9 and 12 for the median, upper lateral and lower lateral groups respectively. These numbers are rather smaller than those prevailing in typical *ulmi*, and the individual groups are of a more elongate form. Average length of adult female 1 mm.

On apricot, Governor's Bay, 1922.

Fig. 8. Pygidium of adult ♀ of : *a*, *Lepidosaphes ulmi* var. *novozealandica*, n. : *b*, *L. ulmi* (typical) ; ×220.

Lepidosaphes epiphytidis, Mask.

On *Astelia cunninghamii*, Wellington, 7.ix.1921.

Having no typical material for comparison, I have to accept this determination—as submitted—on trust. Leonardi does not include it in his review of the genus *Mytilaspis*, but quotes the name only in a list of species that require further study. Maskell's description (N.Z. Trans., xvii, p. 21, 1884) reads as follows :—

" *Mytilaspis epiphytidis*, sp. nov. Female puparium flat, pyriform, brown in colour, thin ; length about $\frac{1}{11}$ inch. Male puparium narrower than that of the female, and a good deal darker, being sometimes almost black ; length about $\frac{1}{20}$ inch ; not carinated. Adult female of normal form of *Mytilaspis*. Abdomen ending in two median lobes ; along the edge several deepish curvilinear incisions between which are some strong spines. Five groups of spinnerets ; lower pair with 14–16 orifices, upper pair 12–16 ; uppermost group 4–6. On *Astelia cunninghamii*, an epiphyte on numbers of our forest trees."

With the exception of his particular remarks upon the male and female puparia, Maskell's description and figure would fit any one of a dozen species. The identity of the host-plant, and the rather unusual sexual difference in the colour of the puparia —which are exactly as described by Maskell—incline me to believe that we are dealing with the same species. But the microscopical characters of the insect submitted by Dr. Myers are quite alien to those of the genus *Lepidosaphes*—as now recognised. While retaining the original specific name, I am erecting a new genus (for which I propose the name *Symeria*) for its reception and am at the same time giving a more detailed description of the species.

Genus **Symeria,** nov.

Species resembling *Lepidosaphes* in the structure of the male and female puparia ; but differing from typical species of that genus in the presence of ligulate and laciniate squamulae on the pygidial margin, in place of the usual gland spines, which are entirely absent. (In Kuwana's species *Tsukushiaspis* both squamulae and gland spines are present.) Genotype, *Lepidosaphes epiphytidis* (Mask.).

Symeria epiphytidis (Mask.) (fig. 9).

Puparium of female pyriform, broadly rounded posteriorly, depressed ; exuviae stramineous, appendix pale brown ; length 2 to 3 mm. Male puparium narrow, with parallel sides, depressed, more particularly on posterior half ; dark brown to blackish ; length approximately 1 mm.

Adult female long-ovate, broadest across the middle. Margins of abdominal segments moderately produced. Antennal tubercle (fig. 9, *b*) normally with 4 long and stout curved bristles. Anterior spiracles each with a small group (averaging 6) of parastigmatic pores. Posterior spiracles without associated pores. Margins of metathorax and abdomen with clusters of tubular pores. Perivulvar pores in five groups, more or less confluent ; median 6–9, anterior laterals 10–17, posterior laterals 8–12. Margin of pygidium (*a*) with a pair of large and prominent median trullae,

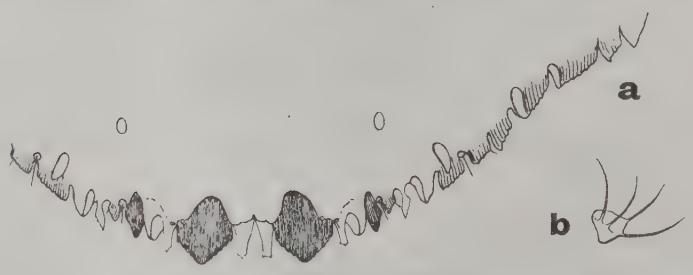

Fig. 9. *Symeria epiphytidis*, Mask., adult ♀ : *a*, pygidium ; *b*, antenna ; ×450.

separate from each other by about the width of one of them, their free margins bluntly conical and serrate ; with one pair only of small duplex lateral trullae, of which the inner lobule is the larger, both lobules with their outer margins sloped and very slightly indented ; a pair of prominent ligulate squamulae, with laciniate apices, between the median trullae ; a similar squamula immediately exterior to each median trulla ; and an outwardly pectinated squamula following the lateral trullae, beyond which the margin is coarsely cristate ; marginal pores large and associated with conspicuous prominences ; dorsal tubular pores sparse. Length averaging 1·5 mm.

Nymphal exuviae without a median hyaline transverse division.

Anoplaspis metrosideri (Mask.)

On *Metrosideros robusta*, Wellington, 18.v.1921.

This is the *Mytilaspis metrosideri* of Maskell, for which Morrison erected the new genus *Anoplaspis*.

Anoplaspis maskelli, Morrison.

On *Metrosideros scandens*, Motueka (*G. Brittin*).

Amongst material distributed by Maskell as *Mytilaspis metrosideri*, Morrison found a distinct species which he also refers to the same genus. It is interesting to

find both species in Dr. Myers's collection, though he apparently received this second species from Mr. G. Brittin, who collected it in a different locality and upon a different species of *Metrosideros*.

Fiorinia myersi, sp. n. (fig. 10).

Puparium of female very pale stramineous; flattish, completely covering and concealing the large nymphal exuviae; narrow in front, widening behind.

Nymphal pellicle (fig. 10, *d*) pale stramineous, translucent, enclosing the adult female insect, which is apparent as a reddish brown blotch at the anterior end; rounded in front and laterally, the abdominal area narrower, the posterior extremity pointed. Length 1·5 mm; breadth 0·8 mm. Pygidial margin (*e*) with six prominent chitinous trullae; the median and inner lateral pairs narrow, strongly produced, sloping from the outer side to the apex, which forms an acute angle with the longer

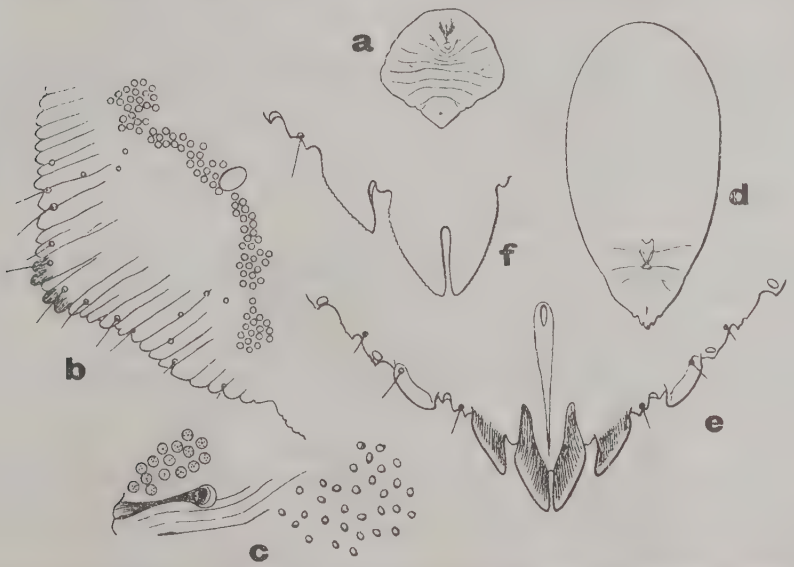

Fig. 10. *Fiorinia myersi*, sp. n.: *a*, adult ♀, ×30; *b*, pygidium, ×300, and *c*, anterior spiracle, ×450, of adult ♀; *d*, nymphal exuviae, ×30; *e*, pygidium, ×300, and *f*, posterior extremity, ×450, of nymphal exuviae.

inner side, the outer edge minutely serrate (*f*)—the median pair produced inwardly at the base; the outer lateral trullae short and broad, minutely serrate; anal aperture very small, narrowly ovate; margin with a few small spiniform setae, but completely devoid of squamulae.

Adult female (*a*) short and broad, the breadth (0·65 to 0·75 mm.) equalling or slightly exceeding the length. Antennal tubercles with 4 or 5 setae, two of which are markedly shorter than the others. Mouth-parts large and conspicuous. Anterior spiracles (*c*) each with a cluster of about 15 parastigmatic pores and associated with a larger cluster of minute rounded tubercles; the posterior spiracles without either pores or grouped tubercles. Pygidium (*b*) broadly deltoid; the margin cut into numerous lobules, amongst which it is difficult to select any as representing definite trullae, except possibly the two on each side of the median point, which are denser

and rather more prominent than the remainder. The usual marginal setae are long, projecting far beyond the lobules. The broadly ovate anal orifice occupies a central position. The perivulvar pores form a more or less continuous, flattened arch, though the lower groups are often separate. They are normally disposed across the basal area of the pygidium, but are often backwardly displaced (as in the example figured).

This very distinct species was taken by Dr. Myers on *Astelia solandri*, at York Bay, Wellington, in close association with *Lepidosaphes asteliae*. The puparia of the two species are, superficially, very similar. I have received the same species from Mr. G. Brittin, who found it upon a species of *Astelia* at Nelson.

Poliaspis intermedia, Fuller.

On *Olearia fragrantissima*, Banks Peninsula, xi.1920 (*Esmond Atkinson*).

These examples, with their prominent median trullae, agree exactly with the species described and figured by Fuller.

Poliaspis media, Mask.

On *Veronica halkeana*, Kaikoura, xi.1922 (*Esmond Atkinson*), also on *Coprosma arborea*, Te Paki, N. Auckland, 12.xii.1923.

In this species the median trullae are recessed and do not project beyond the margin of the pygidium.

Chionaspis dysoxyli, Mask.

On *Melicytus ramiflorus*, Wellington, 2.ix.1921.

Though originally described from *Dysoxylon spectabile*, Maskell subsequently recorded the species as " occurring abundantly on *Melicytus*." Dr. Myers's examples agree with Maskell's description and figures as closely as can be expected.

Chionaspis eugeniae, Mask.

On a palm, Invercargill, 5.v.1922 ; associated with *Aspidiotus hederae*, Vall.

Chionaspis dubia, Mask.

On a fern (*Cyathea dealbata*), Wellington, 3.ix.1922.

Maskell makes no mention of a small group of minute conical tubercles that occur shortly behind each of the anterior spiracles. They are, however, noticeable in material determined by himself.

Parlatoria myrtus, Mask.

On *Abies* sp., Wanganui, 1922.

This agrees with examples of *myrtus* ex coll. W. M. Maskell. But whether it is really distinct from *pergandei* is open to question.

Genus **Leucaspis.**

When Maskell published (in 1887) his " Account of the Insects noxious to Agriculture and Plants in New Zealand," the section on " Scale insects " contained no reference to any species of *Leucaspis*. That genus was listed with an asterisk, indicating that it had not yet been found in New Zealand. But two species, *gigas* and *stricta*, then referred to the genus *Fiorinia*, have since been transferred to *Leucaspis*. Dr. Myers's collection contains several species that appear to be distinct from either of these two ; but I have experienced great difficulty in deciding upon the limits of natural variation in the New Zealand members of this group, which seem to be unusually polymorphic. As in most species of this genus, the more useful (because the least variable) characters are to be found on the nymphs.

Leucaspis gigas, Mask.

Diaspis gigas, Mask., 1878 ; *Fiorinia gigas*, Mask., 1889 ; *Fiorinia asteliae*, Mask., 1887.

On *Meryta sinclairii*, York Bay, Wellington (*Esmond Atkinson*) ; and on *Nothopanax arboreum*.

This species is recognisable by the broadly expanded, depressed female puparia, which range in colour from white to ochreous, with varying degrees of translucency. Examples, in my collection, on *Nothopanax* and *Meryta* are white and opaque ; others (coll. G. Brittin), on *Griselinia*, are pale ochreous and translucent. Maskell describes the secretionary appendix as " yellowish brown or dirty white." Mr. Brittin (*in litt.*) maintains that these represent two distinct species—*gigas* and *asteliae* of Maskell ; but I have been unable to distinguish any reliable morphological differences in the insects. Correlated with the texture of the secretionary covering of the puparia is a corresponding difference in the density of the nymphal exuviae, which—at one extreme—are densely chitinized and almost completely opaque, while —at the other—they are thin and translucent. In intermediate forms the gradual increase of density is seen to arise by a deposition of opaque matter in closely crowded rounded pustules producing the appearance of shagreen. The pygidial characters of the nymphs are remarkably constant ; but this is far from being so in the adult females, in which the number of definite trullae varies from 2 to 7, with frequent asymmetry in their arrangement, the full range of variation sometimes occurring within a single gathering. Variation, both in number and symmetry, may arise either by suppression or duplication of one or more trullae.

Leucaspis cordylinidis, Mask.

On a palm, Auckland, 20.viii.1921.

Although *cordylinidis* has not previously been recorded from New Zealand, the specimens submitted by Dr. Myers agree so closely with examples ex coll. W. M. Maskell that I have no hesitation in referring them to that species. Other material, on *Nothopanax arboreum* (York Bay, Wellington, 2.ii.1924), while agreeing in the characters of the adult female, has but a single (submarginal) series of dorsal pores on the nymphal pygidium, as compared with the three concentric series of typical *cordylinidis*.

If, as is possible, Maskell's *stricta* should prove to be identical with his *cordylinidis*, the latter name will have to give way to *stricta*, a description of which (as *Fiorinia stricta*) has priority by nine years. But the exact identity of *stricta* remains obscure.

Leucaspis cordylinidis var. **senilobata,** n. (fig. 11).

Puparium of female (fig. 11, *d*) elongate, narrow, rather strongly convex, straight or variously contorted ; normally dead white, but often discoloured by the adherence of dust and fragments of bark ; larval pellicle with anterior half yellowish and posterior half blackish ; nymphal pellicle completely concealed beneath the white secretionary covering. Length 2·5 mm.

Male puparium elongate, narrow, straight ; similar in form and (approximately) in size to that of the female, but rather less convex and usually recognisable by its cleaner and whiter secretionary appendix.

Nymph elongate, narrowed anteriorly, the segments rather sharply defined. Pygidium (*a*) with three pairs of prominent and heavily chitinized trullae, all more or less definitely trilobate. Squamulae broad, deeply and irregularly serrate ; the series continued along the lateral margins of the abdominal segments and extending to the mesothorax, gradually losing their flattened serrate form and taking up a submarginal position and, finally, on the thorax, assuming the form of conical tubercles similar to those observed on the thorax of the adult female. Margin of pygidium

with a series of large and heavily chitinized lunate pores ; with a moderate number of conspicuous ovate pores on the discal and submarginal areas. The inward extensions of the median and inner lateral trullae are each covered by a large claviform, strongly ribbed chitinous plate ; similar plates are situated, on each side, between the bases of the inner and outer lateral trullae and on each side of the anal orifice. Length of fully developed nymph, measured from the exuviae (*b*), 2 mm.

Adult female (*c*) elongate, broadest across abdominal region, narrowing to the frontal extremity, bluntly pointed behind ; length 1·75 mm. Antennal tubercles situated at a considerable distance from the frontal margin, about half way between

Fig. 11. *Leucaspis cordylinidis* var. *senilobata*, n. : *a*, ♀ nymph, posterior extremity, ×450 ; *b*, nymphal exuviae, ×18 ; *c*, adult ♀, ×18 ; *d*, ♀ puparium, ×5 ; *e*, adult ♀, posterior extremity, ×450 ; *f*, paratrophic pores and tubercles, ×450.

that and the mouth-parts, each with 5 or 6 stoutish curved bristles. Anterior spiracles almost impinging upon the tentorium and anterior to the labium ; each associated with a group of about 15 parastigmatic pores. With a conspicuous, elongate group of paratrophic pores at the apices of rounded or conical tubercles (*f*), each communicating with a short, tubular duct. Posterior spiracles without pores. Anal orifice surrounded by an irregular chitinous patch, with other smaller patches between it and the posterior margin. Perivulvar pores in five distinct and compact clusters ; median with 20–22 pores, upper laterals with 21–25, lower laterals with

18–23; with a small supplementary cluster of similar pores on each side of the two preceding abdominal segments, each cluster averaging 8 pores. Posterior margin irregular and asymmetrical in each of the few examples available for study. In the example figured (*e*) there is a pair of median trullae, one of which is dilated and irregularly 4–dentate, while the other is narrow and bidentate; with a single small, acutely conical lateral trulla on one side only. In other examples there is no vestige of lateral trullae. Squamulae irregular in form, size and position; varying from narrowly lanceolate to broadly truncate, with the free margins irregularly serrate. With an irregular submarginal series of rather short spiniform setae, arising from sharply defined circular tubercles. Similar, but smaller setae are sparsely disposed over the disc of the pygidium and on the two preceding segments.

Adult male of normal form. Genital sheath long and slender. With two pairs of large black ocelli. Total length, 1·5 mm. Expanse of wings, 3 mm.

On twigs of *Griselinia littoralis*, Christchurch, 13.viii.1921.

This form differs from the type in the presence of an additional pair of trullae on the pygidium of the nymph, making 3 pairs, while in typical *cordylinidis* there are two pairs only.

I have given a detailed description of the adult female insect, Maskell's account being inadequate and in parts misleading. He describes the abdomen as "ending in a single median lobe, which is broader than long." This is in direct opposition to the characters presented by examples received direct from the author of the species.

Leucaspis podocarpi, sp. n. (fig. 12).

Puparium of adult female ovate; the larval pellicle naked and projecting anteriorly, the nymphal pellicle concealed beneath the opaque white, closely felted secretionary appendix. Length, 2·5 to 3 mm. Width across median area 1·25 to 1·5 mm.

Nymphal pellicle (fig. 12, *b*) fusiform, tapering to each extremity; with a longitudinal fold (representing the actual lateral margin) on each side of the venter, extending from the frons to the base of the pygidium; junction of segments not clearly defined; dorso-lateral margins with conspicuous duct pores, some of which are elevated upon small conical tubercles, the ducts short, the series extending forwards to the mesothorax. Pygidium (*a*) with four very obscurely trilobed trullae, their bases extending inwards in the form of slender paraphyses; squamulae broad, deeply and irregularly incised, the series extending laterally to the abdominal segments, but not to the thorax; margin with large and heavily chitinized lunate pores; disc of dorsum with numerous similar pores—about 15 on each side of the median line; anal orifice surrounded by a coarsely ribbed area, extending backwards to the base of the median trullae, with three claviform ribbed plates on each side, one associated with the base of each trulla and the third situated about half-way between the margin and the level of the anal orifice. Length, 1·5 to 1·75.

Adult female broadly ovate, widest behind the median area, narrowed anteriorly. Length, 0·5 to 0·75 mm. Frontal area much shorter than the length of the tentorium. Antennal tubercles with one long, stout, curved bristle and four or five shorter setae. Anterior spiracles each with a cluster of about 17 parastigmatic pores. With a crowded group of paratrophic pores on each side of the mouth-parts; each pore on the apex of a small conical tubercle and communicating with a short tubular duct. Anal orifice broadly surrounded by an irregular chitinous plate. Usually with four smaller oblong plates between the anal orifice and the posterior margin. Perivulvar pores in five crowded, more or less confluent groups; with two supplementary groups (each of about 8 pores) on each side of the preceding abdominal segment, and one (also of 8 pores) on each side of the antepenultimate segment. Pygidial

margin (*c*) with six fusiform trullae, the median four of which are equidistant, whilst the outermost trulla on each side is more widely spaced; squamulae few, small and simple, asymmetrically disposed; duct pores (about 10 on each side) rather large and conspicuous, ring-shaped, with thickened rims.

On *Podocarpus totarae*, Christchurch, 2.xii.1920.

Near to (possibly a form of) *cordylinidis*, from which it differs in having six (instead of four) supplementary clusters of ceriferous pores on the abdominal segments and in the reduced number and size of the squamulae.

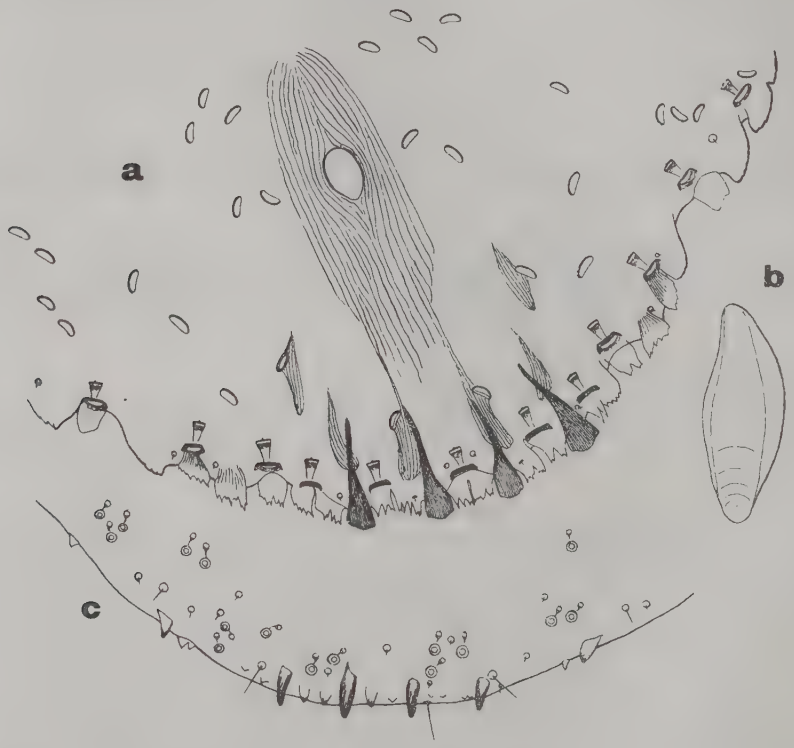

Fig. 12. *Leucaspis podocarpi*, sp. n.: *a*, pygidium of nymph, ×450; *b*, nymphal pellicle, ×18; *c*, adult ♀, posterior margin, ×450.

Leucaspis myersi, sp. n. (fig. 13).

Female puparium (fig. 13, *a*) flattish, irregularly ovate, broadest slightly behind the middle, narrowed anteriorly where the larval exuviae impinge upon the margin; nymphal exuviae occupying the larger part of the central area. Colour uniformly pale, translucent stramineous, except where the body of the insect shows through the transclucent covering as a reddish or brownish patch. Length, 2·5 mm; breadth, 2 mm.

Nymphal pellicle (*b*) ovate, sharply incised at the junctions of the abdominal segments, more particularly immediately in front of the pygidium. Posterior extremity (*g*) with four very slender rod-like trullae scarcely projecting beyond the

margin ; the squamulae and marginal prominences truncate and terminally fimbriate, but becoming narrower and more pointed towards the base of the segment ; the margin with relatively small lunate pores ; oval dorsal pores confined to the submarginal area, none on disc. Anal orifice small. Length, averaging 1·75 mm.

Adult female (*c*) ovate, widening evenly from the rounded frons to the base of the abdomen, thence narrowing rather abruptly to the pygidium, which is prominent and bluntly pointed. Antennal tubercles with three stout, curved bristles. Mouth-parts normal, well defined and conspicuous. Anterior spiracles (*d*) situated close to and slightly in front of the labium ; each associated with a cluster of from 7 to 12 relatively

Fig. 13. *Leucaspis myersi*, sp. n.: *a*, ♀ puparium, ×10 ; *b*, nymphal pellicle, ×15 ; *c*, adult ♀, ×20 ; *d*, anterior spiracular area, ×450 ; *e*, *f*, posterior margin of adult, ×450, and *g*, of nymph, ×135.

large quinquelocular pores and a scattered group of tubular paratrophic pores which, in this species, are sessile. Perivulvar pores in five more or less distinct clusters, of which the median contains from 10 to 17 pores, the anterior laterals from 18 to 25 and the posterior laterals from 9 to 17, without supplementary clusters of pores on the preceding segments. Margin of pygidium (*e*, *f*) normally with 6 ovate, more or less heavily chitinized trullae, but frequently asymmetrical, by the absence of one or more of the trullae, or by a duplication of one of the lateral trullae. In an asymmetrical example (*f*) one of the median trullae is missing, while the outer lateral trulla on that side has been duplicated. In the more typical example (*e*) there are

two prominent, sharply acuminate, fusiform processes between the median trullae, two similar processes between the median and first lateral trullae, and three or four in the interval between the lateral trullae. Marginal and submarginal setae rather long; with small duct pores near the base of each trulla. Anal orifice relatively large, regularly circular, surrounded by an irregular denser area: with four or more elongate plates between it and the posterior margin. Length, averaging 1·75 mm. Breadth across base of abdomen, 1 to 1·25 mm.

On *Pseudopanax crassifolium*, Wellington, 14.ix.1921.

Nearly related to *L. gigas*, from which it may be distinguished by the acutely pointed fusiform processes on the pygidial margin of the adult female and by the broadly ovate trullae. I recognise, however, from a study of material collected by Mr. G. Brittin, on various host-plants, that *gigas* is a very variable species, and it is possible that *myersi* may eventually be found to grade in with extreme forms of Maskell's species.

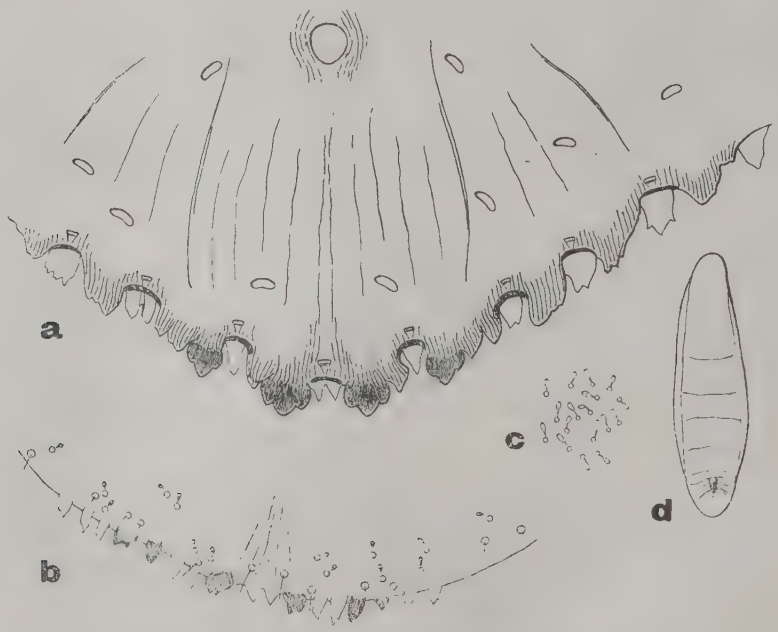

Fig. 14. *Leucaspis brittini*, sp. n.: *a*, pygidium of nymph, and *b*, of adult ♀, both ×450; *c*, paratrophic pores of adult ♀, ×450; *d*, exuviae of nymph, ×18.

It will be convenient to include, here, the description of what I believe to be another new species of *Leucaspis* sent to me by Mr. G. Brittin, who supposed it to represent *L. stricta* of Maskell. I have no authentic material of *stricta*, but have been favoured with the loan of a preparation, from the U.S. Bureau of Entomology, ex coll. Maskell. Referring to this preparation, Mr. Morrison writes me that there was no true type slide of *stricta* in the Maskell collection, and that consequently he cannot guarantee that the specimens under consideration are certainly representative of Maskell's species. He believes, however, that the identification is correct. Relying upon this preparation, it appears that the characters of *stricta* are very similar to those of *cordylinidis* and that in both these species the trullae of the nymphal pygidium are

slender and have long inwardly extending bases. In the species submitted by Mr. Brittin the nymphal characters are so very distinct that I feel justified in describing it as new and am pleased to name it after its discoverer.

Leucaspis brittini, sp. n. (fig. 14).

Puparium of female elongate, slender, rather strongly convex. Larval exuviae exposed, dull brown; nymphal exuviae completely concealed beneath the opaque white secretionary appendix. Length, 2·5 mm. Breadth, approximately 0·75 mm.

Nymph (fig. 14, *d*) elongate and narrow. Length, 2 mm.; greatest breadth, 0·6 mm. The pygidial margin (*a*) shows two pairs of broad, strongly trilobate trullae, without any basal extensions, followed by several heavily chitinized marginal prominences. The membranous squamulae are reduced in number, those situated between the trullae with simple, pointed apices, those nearer the base of the pygidium broader and with irregularly incised apices; each squamula associated with a large, heavily chitinized, lunate, marginal pore. There is a submarginal series of conspicuous sausage-shaped pores on the dorsum, with a similar pore on each side of the anal orifice.

Adult female elongate, narrow. Length, 1·5 to 1·75; breadth, approximately 0·5 mm. Antennal tubercles situated approximately half-way between the frons and the mouth parts; each with from 5 to 8 longish bristles. Paratrophic pores (*c*) sessile, communicating with short slender ducts. Anterior spiracles each with a cluster of from 12 to 15 parastigmatic pores. Pygidium entirely membranous, without any strongly chitinized plates or patches. Perivulvar pores numerous and crowded; the median and upper lateral groups more or less confluent, making it difficult to determine the exact limitation of each group; allowing for this difficulty, the average number of pores may be taken as—median 22, upper laterals 25, lower laterals 20; with a supplementary cluster of from 6 to 8 pores on each side of the two preceding segments of the abdomen. Posterior margin (*b*) with a median pair of rather broad, (usually) bicuspid trullae and a pair of narrower, pointed, lateral trullae; immediately exterior to each lateral trulla is a partly chitinized squamula simulating a second lateral trulla, thus accentuating the probability that trullae are merely modified squamulae; the membranous squamulae relatively small, either pointed or inconspicuously bi- or tridentate with a few (about 7 on each side) minute duct pores distributed irregularly over the submarginal area.

On *Muehlenbeckia* sp., Oamaru (*G. Brittin*).

NEW CURCULIONIDAE (COL.) FROM CULTIVATED PLANTS.

By Guy A. K. Marshall, C.M.G., D.Sc., F.R.S.

The types of the following species are all in the British Museum.

Subfamily Otiorrhynchinae.

Mimaulus matabelenus, sp. n.

♂ ♀. Derm black, with dense mosaic-like sandy-brown scaling variegated with grey and blackish scales ; the pronotum usually with an indefinite pale median stripe ; a greenish grey patch on each side of the prosternum.

♂. *Head* with the frons very slightly convex transversely, the supra-ocular ridge low and not angularly prominent behind ; the eyes relatively rather large and almost circular ; the frons with its anterior margin distinctly narrower than the base of the rostrum and with a faint indication of a median stria. *Rostrum* about as long as its basal width, flattened dorsally and with a very shallow longitudinal impression on each side. *Prothorax* more than twice as broad as its median length, strongly rounded at the sides, widest a little behind the middle, markedly constricted and subtubular at the apex, the constriction continued shallowly across the disk ; the apical margin truncate dorsally ; the dorsum with a shallow median stria and the scales arranged like rosettes round each short spatulate subrecumbent seta. *Elytra* broadly obovate, widest behind the middle, jointly truncate at the base, with very shallow striae without visible punctures: the intervals each with a row of brown spatulate setae, which are narrower and recumbent on the disk and broader and more or less raised towards the sides and apex. *Legs* densely squamose and with rather long erect setae ; the front tibiae with the long process at the external apical angle formed of two contiguous spines, a short curved spine at the inner angle, and with two (sometimes three) spines between them.

♀. Shorter, the elytra subglobular, the scaling on the pronotum not arranged in rosettes, the teeth on the apical margin of the front tibiae (excluding those at the angles) five in number.

Length, 3·0–3·9 mm. ; breadth, 2·0–2·4 mm.

S. Rhodesia : Bulawayo, 3♂♂, 1♀, , i. 1928 (*J. Isgaer Roberts*).

Reported as attacking tobacco.

Distinguished from the two previously known species, *M. testudo,* Fhs. 1871, and *M. papalosus,* Fhs. 1871, by the distinct apical constriction of the prothorax. *M. testudo* is characterised by the broad and very deep sinuation of the apical margin of the pronotum. *M. papulosus* more closely resembles the present species, but is larger and has no median stria on the pronotum ; the setae on the elytra are also much smaller and all recumbent.

Tanymecus arushanus, sp. n.

♂ ♀. Derm black, with fairly dense grey or light brown scaling variegated with irregular and indefinite darker patches.

Head with shallow, confluent and longitudinally striolate punctation, and with very sparse scaling, which is denser along the eyes, but the subrecumbent or obliquely raised scaling dense throughout ; the forehead as broad as the base of the rostrum, slightly convex transversely, and without any median fovea. *Rostrum* distinctly shorter than its basal width (3 : 4), slightly narrowing from base to apex, but shallowly sinuate laterally in the middle, so that only the apex of the scrobe is visible from above ; the dorsum almost flat, sculptured like the head, and with a very feeble median carina;

the apical margin deeply sinuate in the middle and asymmetrical, the right side projecting a little more than the left. *Antennae* with the scape shortly exceeding the hind margin of the eye and somewhat curved in the middle; the funicle with joint 2 evidently shorter than 1 (3 : 4) and slightly shorter than 3+4; 3 to 7 subequal. *Prothorax* as long as broad (♀) or slightly longer than broad (♂), broadest at the middle and strongly rounded at the sides (less so in ♂), the base and apex being of equal width and each slightly arcuate; in lateral view, the apical margin much more oblique than the basal; the dorsum with fine close reticulate punctation throughout the disk, which becomes shallower and more confluent laterally; the scaling uneven, being densest on the basal half of the disk; the setae dense, even and subrecumbent. *Scutellum* very small, triangular and densely squamose. *Elytra* elongate-ovate in ♀, more narrowly elliptical in ♂, with the base shallowly sinuate, the shoulders obliquely rounded and without any humeral callus, and the apex emarginate at the tip, without any trace of a posterior callus and the punctures in the shallow striae not visible through the clothing; the slightly convex intervals with fairly close, small and shortly ovate or subcircular scales, and with almost equally dense, short, cylindrical and obliquely raised setae. *Wings* not functional. *Legs* densely clothed with variegated scales and setae; the front femora thicker than the others, the anterior pairs bearing longer erect hairs beneath on the basal half in ♂; the hind tarsi with joint 1 as long as 2+3, and 2 longer than 3.

Length, 6·6–8·1 mm.; breadth, 2·25–3·0 mm.

Tanganyika Territory: Arusha Chini, 2♂♂, 6♀♀, 24. iv. 1926; and New Moshi, 1♀, 23. iv. 1926 (*A. H. Ritchie*.)

The adults were found by Mr. Ritchie on the foliage of cotton at Arusha Chini.

Very closely allied to *T. destructor*, Mshl. (Bull. Ent. Res. xi, 1920, p. 271, pl. vii, fig. 5), from Southern Rhodesia, which it quite resembles in general facies; but *destructor* has the forehead flattened, the scrobes almost entirely visible from above, and the apical margin of the prothorax not more oblique laterally than the base; moreover the clothing of the elyta is quite different, the very small and shortly ovate scales being very sparse, and the dense flattened recumbent setae looking like narrow elongate scales. (In the original description the clothing was wrongly described.)

Systates habenatus, sp. n. (figs. 1, 2).

♂ ♀. Derm dull to rather shiny black; head, rostrum and prothorax with very sparse narrow white or greenish scales; elytra with a dense stripe of pale green or greenish white scales on interval 8 that does not quite reach either base or apex in ♀ and is still more abbreviated in ♂, an elongate spot behind the middle on interval 6, some sparse scales about the base, and some variable spots of scaling on the declivity (♀ only), otherwise bare and devoid of setae; the sides of the meso-and metasterna with dense greenish white scales, and the venter with sparse narrower scales.

Head rather elongate, narrowing from the base to the eyes; the forehead broadly and rather deeply impressed, with sparse shallow punctures and a deep median stria, the transverse furrow separating the rostrum straight and not angulated; the eyes very convex. *Rostrum* much longer than broad (3 : 2), gradually narrowing from the base to the antennae, then slightly dilated; the median dorsal area unusually narrow, at its narrowest three-fifths the width of the forehead, broadly and deeply impressed in the middle and with very shallow or subobsolete punctation, the lateral margins being sharply carinate; the interantennal area declivous, deeply impressed and shallowly rugulose; the lateral areas simply rugulose. *Antennae* with the scape slender, almost straight, subcylindrical, gradually clavate at the apex, and with fine striolate punctures and very short recumbent setae; the joints of the funicle in order of length: 1, 2, 3, 4, (5, 6, 7). *Prothorax* somewhat broader than long (6 : 5), strongly rounded at the sides, widest at the middle, without any apical constriction; the base truncate,

feebly marginate in the middle only, and distinctly broader than the apex, which is gently arcuate ; the dorsum slightly convex longitudinally, with transversely elongate and more or less confluent, flattened granules, and sparse minute recumbent setae. *Elytra*: ♂, narrowly subelliptical, widest a little behind the middle, obtusely acuminate

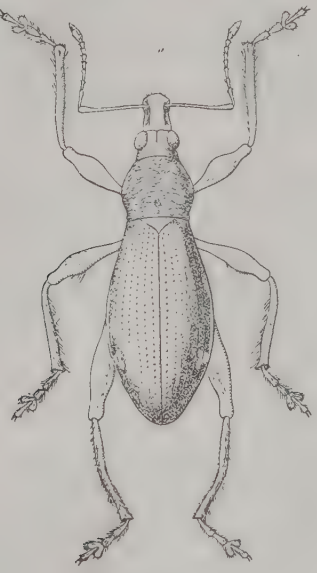

Fig. 1. *Systates habenatus*, sp. n., ♂.

at the apex, and entirely immarginate at the base, where they slope gradually down to the line of fusion with the mesonotum, a considerable portion of the latter being normally exposed, as the prothorax does not fit closely to the elytra; the dorsal outline forming a comparatively flat curve (fig. 2, *a*), which is almost continuous with

Fig. 2. *Systates habenatus*, sp. n., side view : *a*, male ; *b*, female.

that of the pronotum and is highest at about the middle, the posterior declivity being much less steep than usual ; the rows of small, closely set punctures scarcely striate and becoming much shallower behind, the intervals quite smooth and finely aciculate ; —♀, varying in width but always much broader than in ♂, ovate, widest before the

middle, and more acuminate at the apex; the dorsal outline very strongly convex, (fig. 2, *b*) highest at or even before the middle, sloping steeply down to the immarginate base, and with the posterior declivity perpendicular close to the apex. *Legs* black, with sparse setiform pale scales having a metallic reflection; the femora of ♂ with a thin fringe of rather long erect hairs on the lower face; the anterior pairs of tibiae in both sexes with a row of spiniferous granules on the lower edge, these pairs having also in ♂ a fringe of long soft hairs on the lower and posterior faces; the hind tibiae of ♂ curved laterally and flattened on the inner face, which is irregularly set with granules of different sizes, and without any long hairs; the hind tarsi with joint 2 distinctly longer than 3, and all the tarsi of ♂ clothed with longer hairs than those of ♀.

Length, ♂ 5·75–6·25, ♀ 5·75–6·6 mm.; breadth, ♂ 2·0–2·1, ♀ 2·4–3·0 mm.

Tanganyika Territory: Arusha, 3♂♂, 3♀♀, iv. 1926 (*A. H. Ritchie*).

The adults were found feeding on the foliage of cotton.

This species resembles in general facies *S. elongatus*, Aur. 1910, or *S. pyriformis*, Aur. 1910; but apart from the fact that they are quite devoid of scaling, these two species differ in having the median dorsal area of the rostrum very broad and flat, and the forehead is also not impressed.

Subfamily Cholinae.

Cholus pistor bahiensis, subsp. n.

♂♀. Derm rather shiny black, thinly clothed above and below with small whitish scales, leaving exposed very numerous irregular small black dots or flattened granules, without any regular pattern.

Head irregularly punctate, the punctures rugosely confluent near the eyes, more sparse and separated in the middle of the forehead, which has a very deep median fovea. *Rostrum* as long as the head and pronotum, strongly curved, widened at the apex, and with punctures that are fine and moderately close in the basal half, and much finer and more sparse in the apical half; similar in the two sexes. *Antennae* black or piceous, the scape and first funicular joint bare, the rest with fine grey pubescence; joint 1 of the funicle as long as the next three together, 3 longer than broad, 4–7 slightly transverse. *Prothorax* transverse, strongly rounded at the sides, widest at the base, strongly constricted at the apex, which is tubulate and half as wide as the base; the dorsum convex, highest near the base and sloping gradually to the apex, with rather coarse, shallow, often sublunate, more or less confluent punctures, which contain numerous small collections of scales, the interspaces being bare and shiny, and with a very variable smooth median line that reaches the apex but not the base; on the lateral margins and the pleurae the punctures are replaced by granules. *Scutellum* almost circular or subcordate. *Elytra* subtriangular, distinctly wider at the shoulders than the prothorax; the seriate punctation often rather indistinct, the punctures each containing a scale, and the septa usually subgranulate; the intervals with much flattened shiny granules (often transversely confluent) alternating with small patches of scaling, which are also usually confluent laterally. *Legs*: all the femora with a small, fairly sharp tooth of about the same size; the tibiae with a sharp spine near the outer apical angle. *Sternum*: the mesosternal process gently convex.

Length, 12·6–14·4 mm.; breadth, 6·0–6·9 mm.

Brazil: Bahia (*A. Fry, Dr. G. Bondar*).

Bred by Dr. Bondar from the stems of *Paspalum densum*.

The typical form, *C. pistor*, Boh. 1836, differs in its distinctly narrower shape and much denser scaling, the granules on the elytra appearing only as sparse minute dots;

moreover the sides of the pronotum are less strongly rounded, the apex is only feebly constricted and not tubulate, and the dorsum bears flattened granules like those on the pleurae.

The present form is so different in general facies from typical *pistor* that I at first regarded it as a distinct species, but I have since seen two examples (without exact locality) that are apparently intermediate, and I therefore prefer to regard the differences as being merely subspecific.

Subfamily CRYPTORRHYNCHINAE.

Rhyssomatus psidii, sp. n.

♂♀. Colour piceous brown, bare, the elytra, tibiae and tarsi paler ; the elytra with irregular variable confluent blackish patches in the basal half.

Head with close shallow reticulate punctation and without any V-shaped ridge above the eyes, which are narrowly separated above (by about the width of the apex of the scape) and widely separated beneath (by about the width of the rostrum). *Rostrum* of ♂ a little longer than the head and pronotum, stout, with dense longitudinal punctation in the basal half and a narrow low median carina, but without lateral carinae ; the antennae inserted a little beyond the middle, and the apical area with fairly close small rounded punctures ; rostrum of ♀ a little longer and narrower, but otherwise similar. *Antennae* testaceous brown ; the joints of the funicle in order of length : 1, 2, 7, (3, 6), 4, 5 ; joint 1 as long as 2+3, the distal ones as long as or a little longer than broad. *Prothorax* strongly transverse (2 : 1), widest close to the base and rapidly narrowing in front, the sides being almost straight from near the base to two-thirds, then rounding in to the very deep subapical constriction, the basal angles very slightly projecting in ♂ and a little more so in ♀ ; the dorsum opaque and finely aciculate, with numerous low narrow oblique shiny carinae and a broader irregular median carina from the middle to the apex, the interspaces sparsely set with very short dark subrecumbent setae ; the pleurae longitudinally carinate above and with coarse longitudinally confluent punctation below. *Scutellum* small, oblong-ovate, shiny and with only two punctures. *Elytra* ovate, widest behind the very oblique and only slightly prominent shoulders, thence rapidly narrowing to the apex, which is broadly rounded ; the very shallow narrow striae with large punctures superposed, these being very large and more or less oblong on the disk and smaller and rounded towards the sides and apex, every puncture containing a small granule on each side ; intervals 3, 5, 7, 9 carinate throughout, 1 on the apical half only, 8 at the base only, and 10 on the basal half ; the carinae shiny, but the rest of the surface rather dull and finely aciculate, every flat interval with a single row of minute dark recumbent setae, the carinate ones with two rows. *Legs* strongly and closely punctate, each puncture containing a recumbent pale seta; the posterior pairs of tibiae with a sharp tooth on the dorsal edge near the apex. *Sternum*: the prosternal furrow very short, half as long (in the middle) as the front coxae and terminating behind in a transverse ridge in front of the coxae; the mesosternal process distinctly tuberculate, and the metasternum coarsely and closely punctate.

Length, 3·3–4·2 mm. ; breadth, 1·7–2·4 mm.

BRAZIL : Bahia, 1 ♂, 4 ♀♀, 1928 (*Dr. G. Bondar*).

This species is very injurious to guava trees, the larvae attacking the buds.

Allied to *R. novalis*, Germ. 1824, which is larger, with the rostrum rather shorter and more rugose ; the eyes are subcontiguous above and below ; the sculpture of the pronotum is closer, having more the appearance of obliquely confluent punctures, and the median carina is indefinitely continued to the base ; the scutellum is closely punctate ; the elytra with fuscous setiform scaling ; the mesosternal process without a tubercle, etc.

Conotrachelus bondari, sp. n. (fig. 3).

♂♀. Derm black, the apex of the rostrum and the tarsi red-brown ; with very sparse setiform scales ; the rostrum with fulvous scales and two pairs of whitish spots, one about the middle and the other behind it ; the head with fulvous scales and two white spots on the vertex; the pronotum with scattered white scales in the middle of the disk (sometimes forming an indefinite star-like pattern), elsewhere fulvous ; the elytra with sparse fulvous scales along the base, but forming a dense patch from the basal angle to the shoulder (this patch more or less white towards its base), with sparse fulvous scales at the apex (forming denser spots near the apex of intervals 3 and 9), and elsewhere with scattered interningled whitish and fulvous scales.

Fig. 3. *Conotrachelus bondari,* sp. n. ; *a,* side view of head.

Head rugosely punctate, the forehead with a slightly flattened area in the middle and with a short low shiny longitudinal elevation on each side of it ; the eyes in repose covered by the postocular lobes and the frontal space between them as wide as the base of the rostrum. *Rostrum* a little longer than the pronotum, very stout, curved, rugosely punctate and distinctly 5-carinate, except on the sparsely punctate apical area. *Antennae* inserted close to the apex of the rostrum, testaceous brown ; the funicle with joint 1 longer than 2, 3 a little longer than broad, 4 as long as broad, and 5–7 transverse. *Prothorax* very nearly as long as broad, slightly widening from the base to beyond the middle (the sides being almost straight) and there abruptly constricted ; the apical dorsal margin broadly arcuate, and subtruncate in the middle, the base bisinuate ; the dorsum very coarsely and rugosely punctate, with an indefinite abbreviated median carina and with two small obsolescent elevations on the disk just beyond the middle ; the apical area with a broad deep median furrow and an obtuse carina on each side of it ; an almost bare quadrate patch in the middle of the base. *Scutellum* small, longer than broad, elevated, bare. *Elytra* 1·5 times as long as broad, arcuately narrowing from the basal fourth, with the base markedly bisinuate and the shoulders roundly rectangular ; the punctures coarse and rather unequal ; intervals 3, 5, 7, 9, sharply carinate, the others rather narrow, the carina on interval 3 broadly

interrupted before and narrowly behind the middle, that on interval 5 broadly interrupted before and at the middle, the abbreviated carina near the base of interval 10 only slightly elevated. *Legs* with coarse subreticulate punctation, thinly clothed with brown and white setiform scales, and with a ring of denser fulvous scales on the femora; all the femora with a single small tooth; the mucro on the anterior pairs of tibiae of ♂ bifid, that on the hind pair subspatulate and curved downwards, those of ♀ all normal. *Sternum*: the mesosternum flattened between the coxae and angularly prominent in front.

Length, 3·4–4·0 mm.; breadth, 1·5–1·9 mm.

Brazil: Bahia, 5 ♂, 10 ♀, 1928 (*Dr. G. Bondar*).

Reported as being very injurious to custard apples (*Anona squamosa*), attacking the stems, buds and fruit.

Very similar in general facies to *C. cinctipes*, Boh. 1845, which differs in having much smaller postocular lobes on the prothorax that do not cover the eyes when the rostrum lies in the pectoral furrow; the forehead is not flattened, and the space between the eyes is only half the width of the rostrum at its base; the prothorax lacks the two ridges at the apex, etc.

Genus **Metoposoma**, Fst. 1896.

One of the two characters given by Faust (Stett. Ent. Zg., lxxv, 1896, pp. 53, 75) for separating this genus from the nearly allied *Metriophilus*, Fst. 1896, is the sinuation of the hind margin of the first ventrite, and this character is unreliable. It is true that in the ♀ of the genotype, *Metoposoma funebris*, Boh., the first ventrite is distinctly sinuate behind, but it is almost straight in the ♂, and it is clearly truncate in both sexes of several other species that are obviously congeneric. The second character is that in *Metoposoma* the first joint of the funicle is shorter than the second, and *vice versa* in *Metriophilus*. Actually, in *Metoposoma* the first joint is slightly longer than the second.

The two genera can, however, be distinguished as follows:—

Metoposoma. Rostrum stout, neither rugose nor carinate, but with separated punctures, usually forming 2 or 4 irregular rows, and generally with an abbreviated median stria. Mesosternal process truncate behind, the actual opening of the horse-shoe broader than long. Tooth on front femora equal to those on posterior pairs; tibiae densely covered with erect scales, so that the sculpture is concealed.

Metriophilus. Rostrum much more slender, rugose and carinate, at least near the base; without any median stria. Mesosternal process rounded behind, the opening of the horse-shoe a little longer than broad. Tooth on front femora larger than those on posterior pairs; tibiae sparsely squamose.

The species of *Metoposoma* have also a somewhat characteristic facies, due principally to the unusually coarse sculpture of the pronotum, the much enlarged punctures in the juxta-sutural striae of the elytra (least noticeable in *funebris*), and the subtruncate apex of the elytra.

In addition to the genotype, the only other recorded species are, *M. nigrofasciatum*, Champ. 1905, and *M. porosum*, Mshl. 1925; but among older species *Cryptorrhynchus ephippiatus* and *strangulatus*, Boh. 1844, must be transferred to this genus, and probably several others.

Metoposoma canavaliae, sp. n. (fig. 4).

♂♀. Derm dull black; pronotum sparsely covered with very large rounded scales, mostly dark brown, but some paler ones which form an irregular narrow stripe on each side and a short median stripe on the anterior half; elytra with dense pale fawn scaling and having a large common discal patch of dark brown from the base to the top of the declivity, the sides of the patch being sinuate, reaching interval 3 in the middle and

extending to 4 in front and behind, and with a small dark patch behind the posterior callus ; legs with uniform dense fawn scaling ; sternum with rather sparse fawn scales, and a few along the sides and apex of the venter.

Head strongly alutaceous, with coarse close punctures, a very broad and deep median furrow narrowing behind, and a deep transverse impression over each eye ; a few subrecumbent pale scales on the forehead. *Rostrum* about as long as the pronotum, stout, strongly curved, parallel-sided, and shallowly constricted at the base, with a broad deep punctate sulcus above the scrobe narrowing from the base to the antennae and a fine abbreviated median stria ; on each side of the latter two very

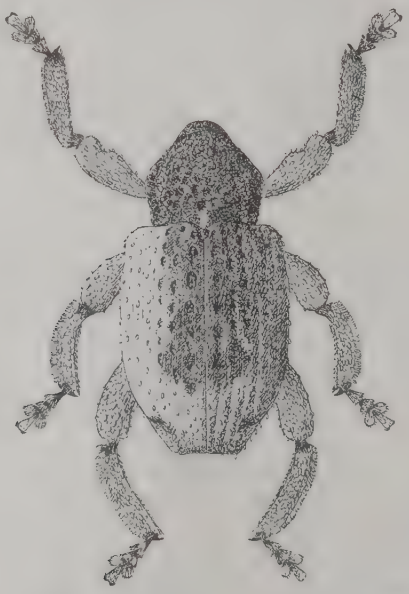

Fig. 4. *Metoposoma canavaliae*, sp. n.

irregular rows of small and rather elongate punctures from near the base to two-thirds, the apical area with irregular denser and more rounded punctures ; rostrum of ♀ more shiny and with rather smaller punctures. *Antennae* piceous, the funicle with joint 1 a little longer than 2, 3–7 bead-like and about as long as broad. *Prothorax* somewhat transverse (9 : 8), strongly rounded at the sides, widest at the middle, and without any apical constriction, the sides being straight in the basal half and the basal angles almost right angles ; the apex strongly arcuate dorsally and half as wide as the bisinuate base ; the dorsum strongly convex longitudinally, highest in the middle, opaque and finely aciculate, with very coarse, more or less confluent punctures on the disk, and with a very short broad median costa adjoining the scutellum ; the punctures on the pleurae much smaller than those on the disk and separate ; a large rounded or broadly ovate scale in every puncture, and no setae. *Scutellum* circular, clothed with scales except in the centre, which is bare and shiny. *Elytra* short and broad (17 : 13), almost parallel-sided from the roundly rectangular shoulders to the middle, then narrowing in a curve to the broadly truncated apex, before which there is a deep lateral constriction, the basal margin being jointly trisinuate, the shallow striae with large deep separated punctures, those in striae 1 and 2 from the base to the top of the declivity and a few at the base of stria 3 much larger and more elongate than the others

and not covered over with scales, the remainder rounded and entirely covered with scaling, their presence indicated merely by a shallow impression containing an isolated larger scale ; stria 9 not more deeply impressed than 8 and competely covered with scales ; the intervals each with a row of subrecumbent broad scale-like setae. *Legs* with very dense large overlapping scales, those on the dorsal edge of the tibiae being erect ; the femora with a small tooth almost obscured by the scaling ; the tibiae broadly compressed and with the outer apical angle forming almost a rounded right angle, the front pair not bisinuate on the lower edge ; the tarsi rather short and joint 2 distinctly transverse.

Length, 7·2–7·5 mm. ; breadth, 3·2–3·4 mm.

Brazil : Bahia, 2 ♂♂, 2 ♀♀, 1928 (*Dr. G. Bondar*).

Boring in stems of *Canavalia* beans.

Subfamily Zygopinae.

Peloropus batatae, sp. n. (fig. 5).

♀. Derm piceous or red-brown, not very densely clothed with variegated setiform or strap-like scales ; head with mostly orange scales mixed with a few white ones and

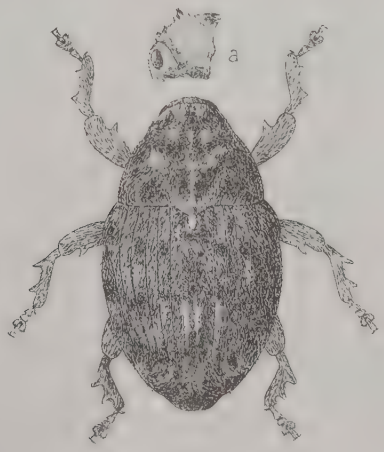

Fig. 5. *Peloropus batatae*, sp. n. ; *a*, side view of prothorax.

a small black spot on each side of the forehead; prothoracic scaling tawny with a few scattered white scales, three small black spots on the front margin, from the middle one of which runs a broad black stripe (enclosing a few tawny scales) almost to the middle of the disk, where it joins an indefinite transverse black band between two dense conical tufts of setae, which are themselves black in the middle and tawny in front and behind, and finally an indefinite rounded black patch on each side of the base ; scutellum buff-coloured ; the scaling on the elytra tawny, interval 1 with erect black scales broken by a dirty white patch at the base, a small white and tawny patch behind the middle and a longer one near the apex, not far from the base a curved tranverse row of small black spots on intervals 3, 5, 7, a similar row before the middle on intervals 3, 5, 8–10, and an indefinite continuous or macular band from interval 1 to 8 across the posterior callus ; the meso- and metasterna with dense fawn scaling ;

the two basal ventrites with thin fawn scaling and each with a large median black patch, the other ventrites with black scales except for a dense lateral patch of fawn on 3 and 4.

Head with dense even small punctures throughout, which are normally mostly concealed by scaling. *Rostrum* about as long as a front femur, gently curved, almost parallel-sided, much wider than deep (except at the extreme base), strongly and confluently punctate in the basal half and there with a distinct median carina, which is especially conspicuous near the base, where it is higher than the level of the forehead; the apical half with a punctate sulcus on each side and strong separated punctures in the middle; the basal half with suberect setiform scales. *Antennae* testaceous, the funicle with joints 1 and 2 subequal in length, 3 and 4 as long as broad, the rest transverse and widening distally. *Prothorax* somewhat broader than long (13 : 11), widest at the base, rapidly narrowing anteriorly, scarcely rounded at the sides, but distinctly constricted near the apex; the apical margin gently arcuate dorsally, and the median basal lobe excised at the end; the dorsum flat in the basal half and sloping very steeply in front, with small dense subreticulate punctures throughout and two large dense conical tufts of long erect setiform scales in the middle of the disk separated by more than their own height; the scales in the middle of the disk and along the apical margin also erect or suberect but much shorter, and the scales in the middle of the base broader than the others. *Elytra* broadly ovate, widest just behind the obtuse shoulders, obtusely rounded at the apex and deeply impressed behind the prominent posterior calli; the deep striae with shallow separated punctures, the intervals almost flat, broader than the striae and with dense rugose punctation; interval 1 with the scales long and erect or suberect almost to the apex, and the scales denser and partly suberect on intervals 3, 5, 7, so that they appear to be higher than the others. *Legs* with fairly dense narrow tawny scales and a few paler and darker ones; all the femora with a large and very sharp tooth; the tibiae with a long deep excavation on the posterior face for the reception of the tarsi, and all with two long sharp teeth on the dorsal edge, the basal tooth on the hind pair being broader and more obtuse than the others.

Length, 3·6 mm.; breadth, 2·1 mm.

Uganda: Kampala, 3 ♀♀, iv.1928 (*G. L. R. Hancock*).

Bred from sweet potatoes.

Nearly allied to *P. ulula*, Gyll. 1836, which is a larger insect (4·5×3·0 mm.) and has the prothorax proportionally broader and rather more strongly constricted at the apex, and the median anterior dark stripe on the pronotum is absent; moreover the basal dorsal tooth on the hind tibiae of *P. ulula* is smaller than in the new species, the length of its vertical posterior edge being less than the depth of the tibia just beneath it and much less than the space between the two teeth, whereas in *P. batatae* this tooth is about equal to each of the two measurements mentioned.

THE EARLY STAGES AND MALE HYPOPYGIUM OF *ANOPHELES ARGENTEOLOBATUS*, GOUGH.

By B. De Meillon, M.Sc.,
South African Institute for Medical Research.

Amongst a number of larvae collected in the Yokeskei River, about twelve miles from Johannesburg, on 31.v.1928, two were found which appeared to be new. These subsequently pupated and finally hatched, one on 15.vi.1928 and the other on 18.vi.1928. The adults were seen to be *Anopheles argenteolobatus*, Gough. Repeated collecting after this has failed to reveal further specimens. Larvae of the following mosquitos were found in the same pool : *Anopheles squamosus*, *A. cinereus*, *A. rufipes*, *Culex salisburiensis*, and *C. theileri*.

A. argenteolobatus does not figure in the collections of Ingram & De Meillon (1927), neither has it been taken by us during surveys since that date. This mosquito is, therefore, either very rare in the Transvaal and Zululand or, what is more probable, one with habits similar to those of *Anopheles gambiae* in certain districts, *i.e.* a sudden appearance in a locality and then again an apparent absence for a considerable period which may extend over years.

In the description of the pupa given below the terminology introduced by Macfie (Bull. Ent. Res. x, pp. 161–169) for the chaetotaxy of the pupa of *Aëdes* (*Stegomyia*) *argenteus* has been adopted.

The Larva.

Head : Inner clypeal hair consisting of a main stem with several rather delicate branches ; outer clypeal hair about three-quarters of the length of the inner, resembling that of the larva of *A. squamosus* but not tufted to the same degree. Pre-antennal hairs simple, rather delicate and slightly shorter than the outer clypeal hairs (fig. 1, *b*). *Antenna* slightly spiculated internally, bearing a small delicate hair on the shaft more or less one-third up from the base and another hair of three branches at the apex between the terminal spines (fig. 1, *a*). *Thorax* : anterior and posterior ventro-lateral thoracic tufts accompanied basally by well developed chitinous spines similar to those of the larva of *A. squamosus*. *Abdomen* : palmate hairs present on segments 1 to 7, but rudimentary on 1 and 2. On segment 1 the palmate hair is delicate and small with about nine leaflets; it is large on segment 2, but equally rudimentary. Palmate hairs are small but fully developed on segments 3 to 7. The average number of leaflets in a palmate hair is sixteen and the average length of a leaflet is 0·08 mm. Filaments are on the average about one-third of the length of the leaflets (fig. 1, *c*, *d*, & *e*). The lateral comb consists of from four to five long spines and about twelve smaller spines which are less than half the length of the longer ones (fig. 1, *f*).

Described from two larval pelts.

Locality. Yokeskei River, about twelve miles from Johannesburg, Transvaal.

Habitat. Larvae were obtained from a small unshaded rock-pool containing *Spirogyra*.

The Pupa (fig. 2).

The trumpets slightly more infuscated than the rest of the cephalothorax, the ratio of the length of the meatus to the total length as 1 : 1·3. The paddles flat-topped, as in the pupa of *Anopheles squamosus*, each bearing on its outer side a row

of spines instead of the delicate fringe to be found in the majority of South African Anopheline pupae. In this respect it resembles the pupa of *squamosus*, *theileri* and *cinereus*. The terminal seta of the paddle curved and fairly long, the seta before the apex small, delicate and branched apically; the midrib very feebly developed and practically invisible, the external buttress well developed. The ratio of the greatest length to the greatest breadth of a paddle is as 1·6 : 1.

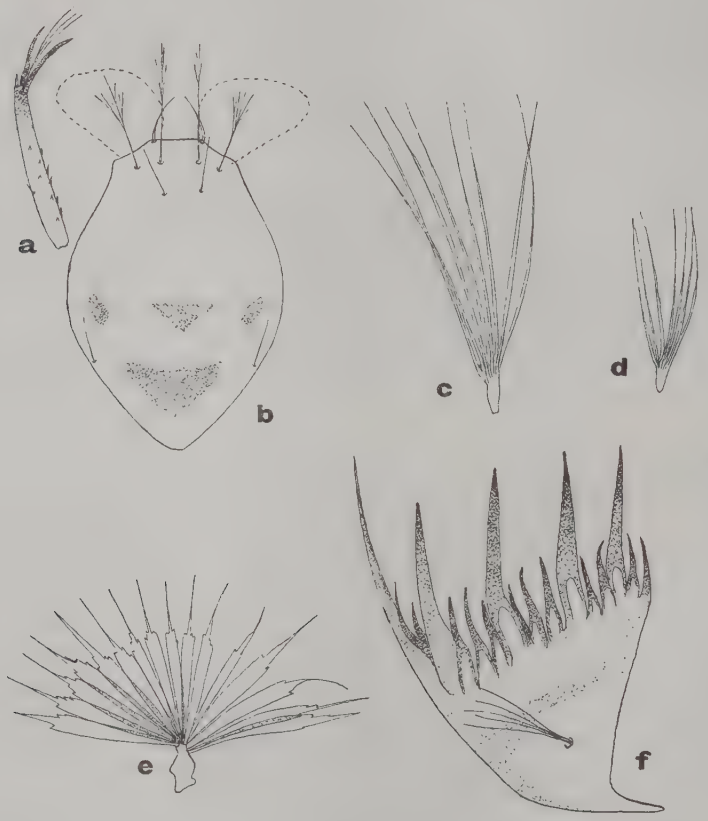

Fig. 1. The larva of *Anopheles argenteolobatus*, Gough: *a*, antenna; *b*, portion of head; *c*, *d*, *e*, 2nd, 1st, 4th abdominal palmate hairs; *f*, lateral comb.

Seta P, at the base of the paddle, is a small delicate hair with a branched end. Seta A (lateral) feebly chitinised on all segments; on segment 8 it consists of a central stem with five to six lateral branches on each side; on segment 7 it is a simple spine about half as long as segment 8, then gradually decreases in length up to segment 2, where it is minute. Seta B (sublateral) is a delicate hair of five to six branches on segments 7 to 2, never exceeding the succeeding segment in length. Seta C (submedian) similar to seta B except that it is a little longer and less branched. A seta, apparently C, is branched and well developed on segments 3 to 7, being more

prominent than is usual in the pupae of South African Anophelines, with the exception of the pupa of *A. squamosus*.

Described from a single pupal pelt.

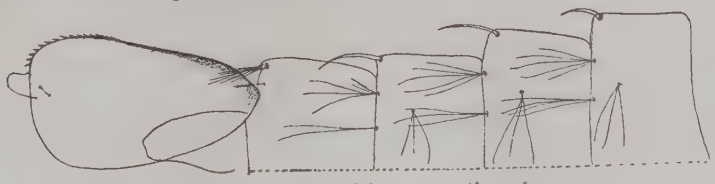

Fig. 2. *A. argenteolobatus*: portion of pupa.

The Male Hypopygium (fig. 3).

Only one specimen was available for examination and this was markedly asymmetrical. The asymmetry in the case of the claspette spines is unusual. Christophers (1915–16) has made prominent use of these spines in separating certain groups of Anophelines and remarks of them that "The arrangement and characters of these hairs is remarkably constant."

One side-piece carries five claspette spines, whilst the other has only three; below each of these clusters and slightly removed from them is another spine, which is

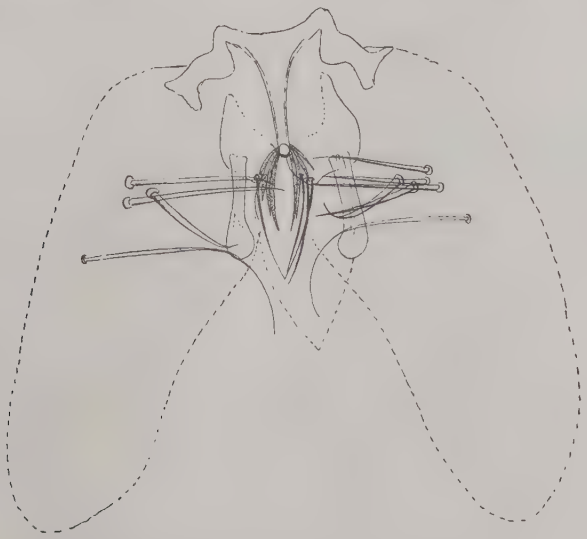

Fig. 3. *A. argenteolobatus*: ♂ hypopygium.

longer and thinner. The harpagones are small, rounded and hairy on their inner sides. The harpago of one side carries three equally long hairs, of which the centre one is more or less apical. The other harpago has an apical hair as long as that on the first mentioned harpago and a small (about half the length of the apical) internal accessory hair. Each harpago carries a club which is longer than the harpago itself and about as long as the apical hair. The theca carries a number of leaflets, the longest of which appears to be rather less than half the length of the theca. The anal lobe reaches to about the middle of the side-pieces.

The hypopygium resembles that of *Anopheles squamosus* and *A. pharoensis* in having the club longer than the harpago and in this respect differs from all other South African Anophelines so far examined.

References.

CHRISTOPHERS, S. R. (1915). The Male Genitalia of Anopheles.—Ind. Journ. Med. Res. iii, pp. 371–394.

INGRAM, A. & DE MEILLON, B. (1927). A Mosquito Survey of certain Parts of South Africa, with special Reference to the Carriers of Malaria and their Control.—Pub. S. Afr. Inst. Med. Res., iv, pp. 1–81.

NOTES ON THE BREEDING-PLACES OF *AËDES* (*FINLAYA*) *NOTOSCRIPTUS*, SKUSE, IN QUEENSLAND.*

By R. Hamlyn-Harris, D.Sc.,
City Entomologist, Brisbane.

It is noteworthy that the breeding-places of different mosquitos vary with the seasons and that mosquitos are influenced in the selection of their breeding-places by such differences as those of temperature, relative humidity, cloudiness and rain, or alkalinity and food supply, and a further study of the breeding-places of *Aëdes* (*Finlaya*) *notoscriptus*, Skuse, has revealed some interesting details worthy of record. In this respect the importance of continuous mosquito work becomes particularly apparent, because at times the results obtained seem almost to be of a contradictory nature ; but these variations are due to the diverse conditions under which mosquitos are forced to live in a country which at one time is subject to excessive rains and at another in the throes of a great drought. These factors tend to give to certain mosquitos an economic significance, and therefore we must not be surprised to find a semi-domestic species like *A. notoscriptus* displaying at times a tendency to become domestic ; this mosquito has already taken to breeding in water-tanks in Western Australia, and fears of its doing so in Brisbane, when its present breeding-places have been largely done away with, seem justified.

Cooling[2] has said that this species is not very plentiful, but our surveys entirely disprove this statement.

The conditions under which *A. notoscriptus* will breed seem to be fulfilled when the water of selection is not situated on the ground but is contained in some receptacle well-sheltered by suitable vegetation and affording a plentiful food supply ; hence its primal love of tree-cavities, the sulci of plants and similar breeding-places in and around ferneries, bush houses, etc. But the presence of *A. notoscriptus* in such large numbers in the Brisbane Cemeteries is significant in view of its dislike to direct sunlight. This is one of the factors guiding it in the selection of its breeding-places, and yet many of the vessels in which it is found are exposed to the full force of the sun.

There is not much doubt that this species is on the increase in the Brisbane area, and it is to be found breeding in all sorts of artificial water-containers, and particularly in very large numbers in the broken ends of bamboos in gardens after rain. Wherever bamboos exist in the Brisbane area, there *A. notoscriptus* is to be found breeding, so long as water is available, all the year round, so that it may be said to have no seasonal occurrence. Breeding-places in bamboos are almost impossible of effective control except by the total destruction of the whole clump—a measure that does not meet with universal approval.

The choice of such breeding-places as the leaves of the wild pineapple (*Bromelia*) is very natural to a tree-hole breeder. Such plants frequently have a number of central cups (base leaves) capable of holding about 50 cc. of water, and in practically every one of these can be found larvae of this species. If Bromeliaceae are found growing at some distance from human habitations, *A. argenteus* does not as a rule select them, though *A. notoscriptus* does so persistently.

The examination of some hundreds of specimens of water in which this mosquito was breeding has revealed the fact that they are for the most part alkaline. In

* From the Entomological Section of the Dept. of Health, Brisbane City Council, Queensland.

surveys of the Brisbane Cemeteries particularly, it is noticeable that only very rarely is a jar found with water on the acid side of neutrality. In the field, too, *A. notoscriptus* seems to prefer an alkaline water, though numerous " traps " placed among trees, bamboos, etc., in the open, frequently yield water with a pH in the region of 6·5, which is however mainly selected by *Culex fatigans*, Wied., and only rarely by *A. notoscriptus*. From these observations it would appear that acid waters are generally avoided and only selected when necessary or possibly by accident.

Toowong Cemetery is one of the oldest and largest of the Brisbane Cemeteries and contains a vast amount of permanent masonry, so that many of the attended graves are incapable of breeding mosquitos; but it is in those portions of the cemetery where there are many neglected graves that the principal breeding-places exist. Mosquitos are more plentiful in hollows protected from the wind, but the figures naturally vary with rainfall, etc. The following proportions of neglected graves may be taken as fairly typical of conditions found during the winter of 1927 at the commencement of our surveys.

Toowong Cemetery—December 1926.

Total number of graves examined	Neglected	With vessels	With vessels containing water	Vessels with larvae
4,715	3,050	2,920	2,604	1,395

A survey of Toowong Cemetery with a view to discover potential breeding-places yielded the following results :—

Graves examined during winter months of 1927	21,237
Graves found to contain vessels of one sort or another ...	15,644
Of these, graves found to be actually breeding mosquitos ...	7,713

A survey based upon a careful examination of 150 graves gave interesting results, 73·5 per cent. of these graves having been found to be infested.

Toowong Cemetery— July–August 1927.

(Mean temperature, 59·3°.)

Mosquito	Percentage of each species found breeding	pH Range	Hay infusion smell	Remarks
A. notoscriptus alone ...	38·6	7·0–8·2	29·3	
C. fatigans alone ...	18·6	7·2–8·0	7·3	
A. argenteus alone ...	0·3	7·6	0·3	
Association of *A. notoscriptus* and *C. fatigans*	16·0	7·0–8·2	8·6	
No larvae	26·5	7·2–8·4	8·6	

Toowong Cemetery— November 1927.

(Percentage of graves infested, 45·9 ; mean temp., 73·3°.)

Mosquito	Percentage of each species found breeding	pH Range	Hay infusion smell	Remarks
A. notoscriptus alone ...	19·2	6·6–8·0	42·3 per cent.	This survey was made 3 months after nearly all vessels containing larvae had been emptied.
C. fatigans alone ...	17·2	7·2–8·0		
Association of these two	7·6	7·4–8·2	31·1 per cent. had a disagreeable manure-like smell.	
Association of *A. notoscriptus, C. fatigans* & *A. argenteus*	1·9	7·4		
No larvae	54·1	6·6–8·4		

South Brisbane (Dutton Park) Cemetery—June 1927.

(No. of graves, 165 ; infested, 91·2 per cent. ; mean temp., 60·4°.)

Mosquito	Percentage of each species found breeding	pH Range	Hay infusion smell	Remarks
A. notoscriptus ...	70·3	6·8–8·4	42·4 per cent.	Only a single association of *A. argenteus* and *C. fatigans* was noted.
A. argenteus	8·4	6·8–8·2	0·3 per cent.	
C. fatigans	10·9	6·0–7·8	0·4 per cent.	
Association of *A. argenteus* and *C. fatigans*...	0·6	7·8	0·6 per cent.	
No larvae	9·8	6·6–8·0	—	

South Brisbane (Dutton Park) Cemetery—November 1927.

(Percentage of graves infested, 94·7.)

Mosquito	Percentage of each species found breeding	pH Range	Hay infusion smell	Remarks
C. fatigans alone ...	40·36	7·2–8·2	30 per cent.	40 per cent. of these were breeding in stone or porcelain jars
A. notoscriptus alone ...	38·59	6·8–8·6		
Association of these two mosquitos	15·79	7·4–8·4		
No larvae	5·26	7·0–7·4		

Note.—In this lot 30 per cent. had the characteristic " hay infusion " smell, 20·9 had a very disagreeable manure-like or decaying vegetable smell, and 19·4 had no smell ; these latter were evidently vases containing comparatively fresh flowers.

Balmoral Cemetery—October 1927.

(No. of graves, 86 ; infested, 56·9 per cent. ; mean temp., 67·8°.)

Mosquito	Percentage of each species found breeding	pH Range	Hay infusion smell	Remarks
C. fatigans alone ...	56·9	6·5–8·5	60·4 per cent. with an average pH of 7·6	Not a single *A. notoscriptus* was taken in this survey.
Association of *C. fatigans* and *A. annulipes*	1·16	7·6		
Association of *C. fatigans* and *A. argenteus*	1·16	7·8		
No larvae	41·59	7·2–9·0		

It is now recognised that the elimination of preferential breeding-places tends to force mosquitos to choose places of compulsion, and in civic control this result is of importance. During short surveys conducted in 1926 *A. notoscriptus* was found breeding in Toowong Cemetery in solitary isolation, but since so many breeding-places of *C. fatigans* have been disturbed, and in some cases completely destroyed, it is not unnatural perhaps to attribute the increased breeding of *C. fatigans* in these centres to its being forced to seek fresh pastures. The control of gully-traps in the suburbs has, it would seem, contributed to keeping *C. fatigans* constantly on the move, and the cemeteries undoubtedly offer an excellent opportunity for expansion. The total absence of all types of mosquitos, except *C. fatigans*, at the Balmoral Cemetery, occupying a somewhat isolated position on the crest of a hill, is worthy of note ; here it not only breeds in vessels, but also in the empty graves prepared for use, suggesting that it is being hard pressed for suitable accommodation.

It has been difficult to account for the fact that *A. notoscriptus*, so far as observations go, whilst associating with *C. fatigans* has failed to do so with *A. argenteus*,

Poiret. There seems to be no particular reason why the latter, though selecting at times the same class of water as *A. notoscriptus*, should avoid any close relations with this species. After patient examination of each jar and allowing no opportunity of observation to pass, it was discovered that such an association did take place occasionally. Only one case, however, came under notice in the Cemeteries during these surveys, though several instances have been recorded from human habitations. Among these, the two here selected are particularly enlightening :—

(1) In a " liquid manure " barrel kept in the shade of a mango tree, not in use at the time but containing water and dead leaves, débris, etc., the water had quite a pleasant " hay infusion " smell, and on examination yielded the triple association of *A. notoscriptus*, *A. argenteus*, and *C. fatigans* (midwinter 1927).

(2) An association of a different kind was recorded at the end of the summer of 1927, in an ordinary kerosene tin full of water, the combination, which was certainly unusual, took place after heavy rain. The species found were : *Anopheles annulipes* (Walker), *Lutzia halifaxi* (Theo.) (the larvae of which are carnivorous), *A. notoscriptus*, *C. fatigans*, and numerous Chironomid larvae.

Skuse's expressed opinion that *A. notoscriptus* laid egg-rafts probably owed its origin to the observation that *C. fatigans* was frequently found in association with this species.

The occurrence of such large quantities of *A. notoscriptus* in one jar, often far in excess of any other mosquito, seems to be explained by the extraordinary viability of the eggs, which it shares in common with the very similar *A. argenteus*. A fair proportion of vessels, especially glass jars, soon dry up and remain empty until the next rain ; some such jars breeding prodigious quantities of *A. notoscriptus* were particularly found on neglected graves, completely buried in rank grass, and the harm that such neglected graves are capable of doing can hardly be estimated.

In conducting these surveys, which have entailed an enormous amount of work, certain observations have been made which are considered of sufficient importance to be here recorded.

(1) All wide-mouthed jars, bottles, tins, etc., are selected in preference to those whose water surface is not so easy of access.

(2) All vessels which protect the larvae from the sun are chosen in preference to glass bottles.

(3) In many cases the presence of a considerable amount of decaying vegetation affords the necessary protection from direct sunlight, and in such cases the vessel, whether of glass or not, is selected indiscriminately.

(4) Vessels with fresh decaying matter are not selected preferentially.

(5) *A. notoscriptus* larvae thrive best in vegetable matter from which the grosser decomposition products have been eliminated.

(6) Vessels containing asparagus fern, maidenhair, etc., are generally found free from larvae, the ferns seem to create a seclusion difficult of access.

(7) Larvae occur in prodigious numbers in some vases ; some vessels are capable of accommodating *A. notoscriptus* to the extent of hundreds of larvae at a time. In some instances *C. fatigans* egg-rafts are found in such quantities that if it were not for the large mortality of the young larvae the vessel could not possibly contain them. There is evidence also that the larger larvae in such instances become cannibals and prey on the younger generations.

(8) *A. notoscriptus* has on several occasions been found breeding in wells.

(9) The presence of large numbers of *A. notoscriptus* at times in the Brisbane Botanical Gardens can be accounted for by the readiness with which the species

takes advantage of bamboo stems after rain for the deposition of its eggs, and it is in such temporary breeding-places that the viability of eggs assumes significant proportions.

Literature Consulted.

(1) BANCROFT, L. List of the Mosquitoes of Queensland.—Ann. Queensland Mus., no. 8, 1908.

(2) COOLING, L. E. Some common Species of Mosquitoes.—Service Publ. (Trop. Div.), no. 1, Commonwealth of Australia (no date).

(3) COOLING, L. E. The Larval Stages and Biology of the common Species of Australian Mosquitoes.—Service Publ. (Trop. Div.), no. 8, Commonwealth of Australia, 1924.

(4) EDWARDS, F. W. A Synopsis of the adult Mosquitos of the Australasian Region.—Bull. Ent. Res., xiv, pt. 4, 1924.

(5) HAMLYN-HARRIS, R. Notes on the Breeding-places of two Mosquitos in Queensland.—Bull. Ent. Res., xvii, pt. 4, 1927.

(6) HILL, G. F. Notes on the Habits and Distribution of some North Australian Culicidae.—Service Publ., no. 21, Commonwealth of Australia, 1922.

INSECTS INJURIOUS TO SUNFLOWER IN UKRAINE.

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Central Station for Protection of Plants in Ukraine.

The cultivation of the sunflower (*Helianthus annuus*) in Ukraine is of great importance, especially in the eastern part, which suffers much from drought. In this area the sunflower constitutes the largest single crop, even exceeding maize, owing to its greater capability for withstanding drought.

The steady home and foreign demand for sunflower products had, until recently, led to a continual increase in the area under cultivation. Nevertheless in 1926 there was an unexpected decrease in the planting of sunflower ; in 1925, according to official information, the total number of hectares occupied in Ukraine by sunflower was 724,000 ; in 1926 this figure decreased to 533,000 hectares, that is, by 26·4 per cent.

The Ukraine Commissariat of Agriculture has investigated the subject very fully. Undoubtedly the most important reason for the decrease has been the fall in prices ; in addition to which the continuous cultivation of sunflower in Ukraine has led to the development of a number of insect pests and diseases.

Among the fungus diseases the most frequent are those caused by *Sclerotinia libertiana* and *Puccinia helianthi*. The parasitic plant, *Orobanche cumana*, which attacks the roots, is also of considerable importance. And lastly, even greater harm is caused by insects, of which the sunflower moth, *Homoeosoma nebulella*, Hb., must be regarded as the most serious pest.

The Central Station for the Protection of Plants, therefore, at the request of the Ukraine Commissariat of Agriculture and supported by the " Maslotrest " (oil-trust), made an investigation into the insects attacking sunflower in Ukraine during 1927. A great deal of useful information was collected which, together with previous observations, renders it possible to give a fairly comprehensive summary of the pests of this plant in Ukraine.

Calliptamus italicus, L. (fig. 1).

This grasshopper unexpectedly appeared in large numbers in 1921–25, causing great devastation in the steppe districts. Generally, weeds of different species, such as *Carduus, Artemisia, Verbascum, Convolvulus, Salvia* and others, serve as food for this insect ; but when it occurs in swarms, it turns its attention to various cultivated plants. The sunflower suffers more severely from these insects than any other crop. The smaller plants are wholly eaten up by the young grasshoppers ; but the older plants generally lose only the lower leaves.

For the destruction of the young grasshoppers poisoned bran bait is mostly used, with great success ; but spraying or dusting is often found to be more convenient. It frequently happens that the inhabitants have not a sufficient quantity of poison available, and in such cases less satisfactory measures have to be adopted. Thus, the young grasshoppers may be driven, with the help of brooms, into pits or trenches and covered up with earth ; or they may be destroyed by burning. In the latter case, heaps of straw are strewn over the fields, and in these the insects readily hide, so that they can be burned without difficulty. Hopperdozers cannot be used for the protection of such tall and frail plants as the sunflower.

Elateridae.

The larvae of these beetles do considerable harm to the roots of sunflowers. The following species have been recorded : *Agriotes sputator*, L., *A. gurgistanus*, Fald.,

Athous niger, L., and *Melanotus brunnipes*, Germ.; but this list could doubtless be added to.

There is no really effective means of combating these wireworms, though many have been tried. Agricultural methods must be applied in the first place, in order to improve the cultural conditions of the soil. If these are continued for a number of years the larvae in the soil may be reduced to almost negligible proportions.

Tenebrionidae.

The larvae of *Blaps halophila*, Fisch., and *Blaps lethifera*, Marsh., often do appreciable injury to blossoming grain and to young sunflowers, sometimes appearing

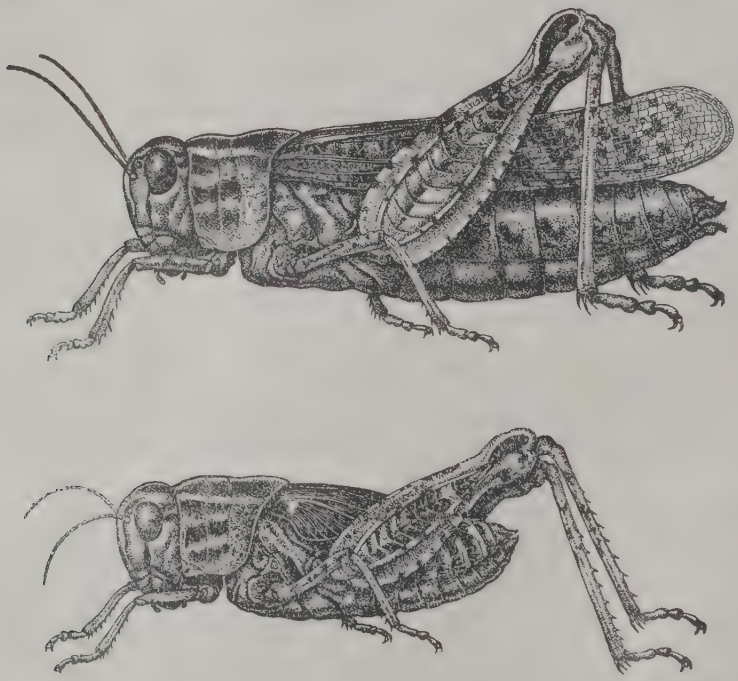

Fig. 1. *Calliptamus italicus*, L., adult ♀ (nat. size 25 mm.) and 5th stage nymph (15–20 mm.).

in great numbers in the drier parts of Ukraine and causing serious harm to the most varied kinds of plants. In addition to these, numerous larvae of *Pedinus femoralis*, L., *Opatrum sabulosum*, L., *Dasus pusillus*, F., and several other species of this family, have often been found at the roots of sunflowers.

The only measure usually applied against these insects is hand-collection and destruction of the two species of *Blaps*.

Mordellistena parvula, Gyll. (fig. 2).

The larvae of this beetle live in the soft core of the sunflower stem, making long winding passages in it. They are often met with in the stems of *Carthamus*, *Aster*, *Cirsium*, *Achillea*, *Cannabis*, *Echium*, and *Daucus*, as well as in other plants. This

insect is one of the commonest and most injurious pests of the sunflower. The beetles generally appear at the end of May, frequenting various kinds of flowers, but are most abundant on sunflowers in June and July.

The females lay their eggs singly in the stem or rarely in the leaf-stalks. For this purpose the beetle lightly pricks the rind of the stem with its sharp ovipositor and lays her whitish, rather elongate oval egg in the hole thus formed, which is not deep, so that the egg is half projecting. The egg is then carefully covered with a semi-transparent sticky white secretion which quickly hardens on exposure to the air. The beetle spends about ten minutes over this. One female lays altogether 10–12 eggs, and rarely more. The larvae hatch on about the 10th–12th day. They then penetrate into the core of the stem and make long winding passages in it, progressing downwards. They winter as full-grown larvae in the stems of the sunflower, which

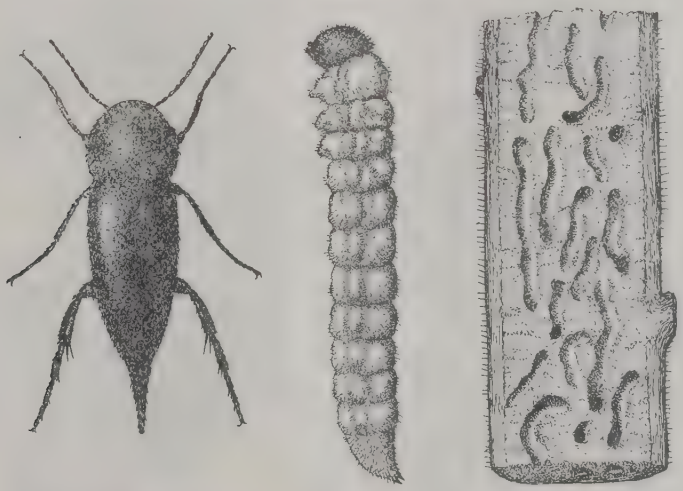

Fig. 2. *Mordellistena parvula*, Gyll., with portion of split sunflower stem showing larval damage. (Nat. size of adult 3 mm., larva 8 mm.)

are generally left on the field after the crop has been collected. The larva makes its way to just beneath the rind of the stem in spring and there constructs a small chamber, in which it pupates. The pupa lies with the head outwards near the rind, which is left intact by the larva. The pupa can be found early in May, and the beetles begin to come out of the stem about three weeks later.

M. parvula is as common a pest in Ukraine as the sunflower moth. A very great number of larvae can be found in a single stem, even as many as a hundred. Badly damaged plants have a stunted appearance and produce light or even empty seeds. Moreover this beetle appears to have some connection with the sunflower disease caused by *Sclerotinia libertiana*, for nearly all the plants injured by *M. parvula* showed signs of this disease to a greater or less extent. Evidently the wound made in the stem by the beetle during oviposition facilitates infection by the fungus.

The burning of the dry sunflower stems after the collection of the crop is a very efficient method of controlling *M. parvula*. The resulting ash makes an excellent fertiliser, rich in potassium salts. In places where no wood is available, sunflower stems are mostly used as fuel, and consequently *M. parvula* is there a rare insect.

Agapanthia dahlii, Richt. (fig. 3).

The sunflower is the favourite host plant of this Longicorn beetle, and often suffers greatly from it. The adult insect is harmless, and the larvae feed in the soft core of the stem, also occurring rarely in *Cirsium, Cannabis,* etc. The beetles appear early in June, being often seen on the flowers of *Carduus, Cirsium, Lappa,* and other plants, principally belonging to the Compositae and Umbelliferae. Later, when the blooming of the sunflower begins, they are chiefly to be found on this plant. In warm sunny weather they are very active and fly readily, oviposition taking place mostly in July. For this latter purpose the female bites large holes in the stem (fig. 3*a*) and lays a single egg in each, the process taking no less than a quarter of an hour. The female generally does not lay again until after an interval of several days ; altogether she is capable of laying 10–12 eggs, rarely more. The larva hatches in 10–15 days and feeds on the

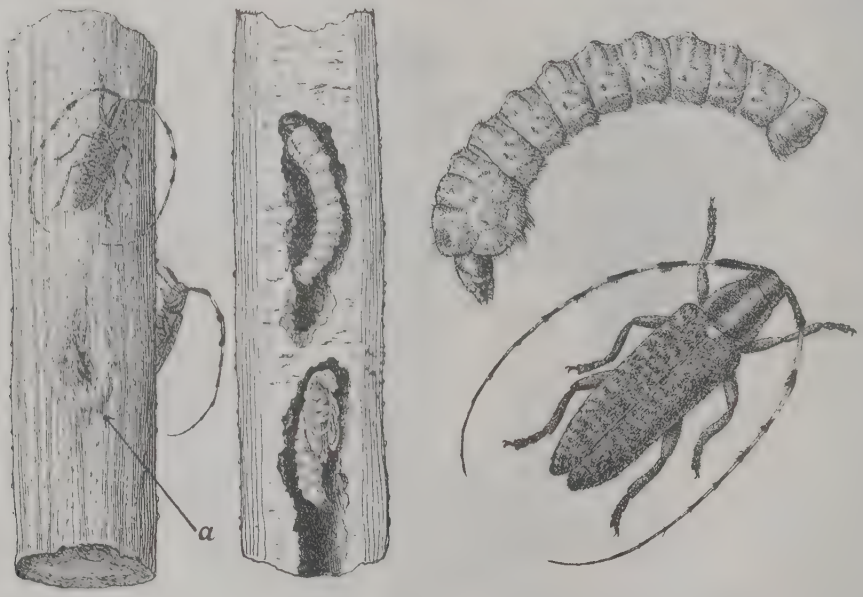

Fig. 3. *Agapanthia dahlii,* Richt., showing, *a,* oviposition hole in sunflower stem made by female with her mandibles. (Nat. size of adult 20 mm., larva 30 mm.)

soft core of the plant, boring downwards towards the root. At first the tunnel is narrow and winding, but later it becomes wider and straighter. In August-September the larva reaches its greatest size (about 30 mm.), by which time the pith of the sunflower appears to have been almost entirely consumed, even to the very root, and the active larva travels freely up and down the stem. The larvae prepare for hibernation in October, in most cases penetrating into the underground part of the stem and closing the tunnel above with a plug of frass. Thus when the sunflower stems are merely cut down to the ground-level, the larvae still remain hibernating in the field, as they are in the interior of the principal root. In such roots the first pupae can be found in the early part of May. The pupa also is very mobile and on being disturbed can travel up and down the tunnel. The adult insect again emerges at the beginning of June.

The sunflower Longicorn is capable of doing considerable damage. Cases are known in which over 90 per cent. of the plants contained larvae of this insect. It was

never possible to find more than one adult larva in a single stem, although one stem often had traces of several ovipositions, doubtless due to different females. Cases are known, however, in which several young larvae were found in one stem, so evidently the strongest larva ultimately destroys its rivals. The larvae of *Mordellistena parvula* are very often met with in stems containing the Longicorn larva; nevertheless, they rarely complete their transformation successfully, as nearly the whole core of the stem is used up by the Longicorn larva. Ultimately, it often happens that insects of the families APIDAE (*Megachile, Osmia*), VESPIDAE (*Odynerus*), etc., build their nests in the stems hollowed out by the Longicorn. The plants containing Longicorn larvae ripen before their due time, yielding light and empty seeds, and the stems are readily broken by the wind.

Fig. 4. *Lethrus apterus*, Laxm., ♂, and profile of head of both sexes. (Nat. size 20 mm.)

The most effective method of control is to burn the roots of the sunflowers. These can easily be pulled up and freed from soil; they make good fuel, and the ash is an excellent fertiliser.

Psalidium maxillosum, F. and **Tanymecus palliatus,** F.

These CURCULIONIDAE at times eat up the leaves of young sunflowers in spring.

Lethrus apterus, Laxm. (fig. 4).

This beetle is a serious pest of many different cultivated plants in Ukraine, and appeared in unusual numbers in several districts in 1927. The beetles normally live almost exclusively on uncultivated land, chiefly on the slopes of hills, at road sides, etc., whence they spread to the crops. They are wingless and appear early in spring, generally in the middle of April, and begin to dig their burrows immediately. The burrow is up to 75 cm. deep, and in its lower part has several short side galleries,

which end in an oval chamber about the size of a pigeon's egg. These chambers are filled by the beetles with a mass of cut and crumpled plants, on which they lay their eggs. For this purpose, on warm sunny days they undertake more or less long excursions in the vicinity of their holes, climbing up their food-plants and biting off pieces, which they drag backwards into their burrows. A quite compact mass is prepared in the hole out of this material, resulting in a kind of ensilage, which serves as food for the larva. The larva develops rapidly, and by the end of June pupae can be found in the chambers. The beetle emerges in about 12–15 days, but remains in the ground over the winter. Thus only 45 to 50 days are necessary for the complete development of *L. apterus* from egg to adult. The young sunflower plants sometimes suffer severely in spring from the attacks of these beetles, which often cut them completely to pieces and carry them off.

Clean-cut trenches make efficient barriers against these wingless insects and are therefore often utilised in Ukraine. Hand-collection of the beetles in pails containing a small quantity of kerosene is also often undertaken, but the insects are easily frightened and on noticing danger quickly, though clumsily, hurry to their holes. Moreover, they do not leave their holes in general on dull cold days. Carbon bisulphide is also a good remedy, a ball of wadding soaked in this liquid being placed in the burrow and then well stamped down with the foot.

Pentodon idiota, Hbst.

This Dynastid beetle mostly injures maize, and rarely sunflower also. The adult insects fly about in the evenings, occurring from the month of April until the autumn. The females generally lay their eggs in July, burrowing into the ground for this purpose. The larva lives in the earth for two years, pupating at the end of the summer, and the adult emerges in autumn but remains in the earth throughout the winter. The beetles gnaw away the neck of the root just below the earth, with the result that the plant withers. The larvae eat round the roots, but the harm they do is less noticeable.

The only control measure adopted is hand-collection of the beetles. If slightly withered plants are noticed, with drooping leaves, the soil around the stem is lightly dug up with the finger and the beetle is found and removed.

Homoeosoma nebulella, Hb. (fig. 5).

The larvae of the sunflower moth constitute the most serious pest of this plant, cases having been known in which a hundred or more larvae were found on a single flower. They are also often found on the blossoms of *Carthamus, Carduus, Sonchus, Onopordon, Centaurea, Lappa* and numerous other Compositae. The life-history of this insect under Ukraine conditions is as follows. The moths appear in June and are found in the greatest numbers in June–July during the blossoming of the sunflower. They remain quiescent on the lower side of the leaves during the day, becoming active only after sunset. Their flight is weak and irregular, and maintained only for short distances. The females search out the ripest blossoms, from which they suck the nectar and in which they also lay their eggs ; they ignore those flowers that are not completely ripe or are too old. From one to four eggs are placed in one blossom, rarely more, and the larvae hatch in about 4–5 days. At first they feed on the pollen, but afterwards on part of the blossom. After this the larvae begin to gnaw into the ovary, passing from one seed to another. They often move towards the centre of the flower, where some of the florets develop later and therefore have softer seeds. Occasionally some larvae will feed on the base or receptacle of the flower, or even on the leaves.

Early in August the larvae commence to make their cocoons, generally starting on the 15th–20th day after coming out of the egg. The cocoons are constructed on

the ground, usually under remains of plants, clods of earth, etc. The larvae normally hibernate in the cocoons and pupate in the spring, but some of them pupate at the end of August or the beginning of September, and after about two weeks give rise to a second generation of moths. Such larvae can be easily distinguished by their larger size, and they make their cocoons chiefly on the sunflower plant, either in the flower or under the leaves and in cracks of the stem. There can be no doubt that these larvae come from the eggs laid by the earliest moths. The few moths of the second generation lay their eggs in September, on the flowers of such late plants as garden aster (*Callistephus*), *Matricaria inodora*, *Sonchus asper*, *Lappa tomentosa*, etc. The larvae of the second generation can be found throughout the autumn right up to the winter. They evidently hibernate in the withered flowers on which they chiefly feed until the first frost. Such wintering larvae quickly revive in warm rooms. They complete their development in spring, producing moths that fly later than the main brood.

The injury done by the larvae of the sunflower moth is generally known and often leads cultivators to cease growing the sunflower, replacing it by other plants. However, it was long ago observed that not all kinds of sunflowers are equally injured,

Fig. 5. Larva of *Homoeosoma nebulella*, Hb., and damaged sunflower seeds (Nat. size 18 mm.)

for in some cases the covering of the young seeds is so hard that the larvae cannot penetrate them, but are forced to feed on the central undeveloped seeds and on the receptacle of the flower-head, which is practically unimportant. Such resistant plants are found to be limited to one variety, other individuals of which are noticeably susceptible, but the two forms cannot be distinguished by any external characters. I. M. Karzin has reared a special kind of sunflower with resistant seeds by crossing the double-petalled, oil-producing Californian sunflower with another kind having hard seeds. The double-petalled plants in the resulting offspring were eliminated, and the remaining individuals, which yielded hard seeds with a good oil content, did not suffer from the sunflower moth at all. The greater hardness of the integument of these seeds was confirmed by chemical analysis; for instance, the seed coats of the new variety have 1·33 per cent. ash, and those of the ordinary oil kind 1·28 per cent.; further, silicic acid in the new variety proved to be 0·0458, as against 0·0340 in the ordinary sort.

The latest investigators, such as D. M. Korolkov and others, conjecture that the resistance of several kinds of sunflower to the sunflower moth depends on the physical structure of the seed coat, and also on certain chemical qualities that are distasteful to the larvae.

The presence of injury to the base or receptacle of the flower-head is a positive sign of resistant qualities, as it shows that the larvae have been forced to abandon the seed. The time of flowering also has some importance, for it can often be observed that the sunflower moth especially harms those flowers that bloom early. It has already been mentioned above that the moths lay their eggs only in the open florets. Unfortunately the sunflower blooms for rather a long time. There are individual flowers that ripen gradually, from the periphery towards the centre of the flower; moreover the oviposition period of the moth is protracted. However, late sowing cannot be recommended, because the sunflower requires much sun and warmth for its ripening.

Many methods for the destruction of this insect have been suggested, but they are all generally of little use. The moths are but little attracted to light and are quite indifferent to sugar baits. Smudge fires have been tried in the fields, but the smoke does not act as a really effective deterrent. For the present, the measure most usually recommended is to sow only such kinds of sunflowers as are least susceptible to the attacks of the moth. It has already been shown above that such sorts undoubtedly exist, and the chief problem of our Plant Breeding Section is to procure a pure strain of this kind.

On the other hand, methods directed towards the destruction of the moth itself are of no less importance. With this aim in view the Central Station made various experiments in 1927. Of these the measure that deserves the greatest attention is the dusting of the sunflower heads with dry insecticides. Only small hand-dusters (holding about 1 lb.) were used, and a small quantity of dust was blown on each flower-head. It was found possible to carry out the work rapidly and efficiently, and the amount of poison required was not great. The insecticides used were calcium arsenate with lime (50 : 50 and 15 : 85) and lead arsenate with sulphur (50 : 50 and 20 : 80), and the dusting was carried out only after the flowers had bloomed, so as to avoid killing the bees. As a result of this, the injury to the treated heads was insignificant, whereas the untreated control plants were heavily attacked. The Central Station intends to continue experiments in this direction on a large field scale.

Homoeosoma nimbella, Zell.

The larvae of the small sunflower moth are often found with those of *H. nebulella*, but in small numbers. The harm they do is negligible. They occur mostly on *Senecio* and other wild Compositae.

Loxostege sticticalis, L.

The larvae of this moth occur occasionally in very large numbers, and they then attack sunflowers, as well as many other plants, entirely devouring the leaves, except the larger veins. They can be controlled by spraying and dusting with arsenicals.

Pyrausta nubilalis, Hb.

Injury to sunflower stems by the larvae of the European corn-borer is also often observed in Ukraine. It is similar to the damage done by this insect to maize, the stems exhibiting round holes through which the frass is ejected. The dry stems which are left after the gathering of the crop should be burnt, as the larvae remain in them to hibernate.

Phytometra gamma, L.

The larvae of this insect attack the leaves of sunflower in the years in which they are numerous. They can be controlled by spraying and dusting.

Heliothis scutosa, Schiff.

The moths emerge in spring from the wintering pupae and are to be found on the blossoms of many different kinds of plants. The females lay their eggs chiefly on *Artemisia*. In July the larvae pupate, giving rise to a second generation, the larvae of which appear in August, and these also feed chiefly on *Artemisia*.

The larvae of the first generation often do considerable harm to sunflower heads. The dusting of the heads, already described under *Homoeosoma nebulella*, can successfully be applied against the larvae *H. scutosa* also.

Barathra brassicae, L.

During recent years the cabbage moth has often appeared in great numbers in Ukraine. The chief injury caused by it has been in fields of sugar-beet, and also in vegetable plots, but at times the larvae do considerable damage to sunflowers by devouring the leaves.

Brotolomia meticulosa, L.

The larvae of this moth occasionally eat sunflower leaves. They are found singly.

Euxoa segetum, Schiff.

The common dart moth attacks the most different kinds of plants, including sunflower. The larvae of the first generation eat the collar of the root below the ground-level at the beginning of summer. The second generation appears late in autumn and does no injury to sunflower.

The only remedy applied is hand-collection of the larvae by digging them out of the earth round withered plants ; though the moths are also trapped with baits of molasses.

Dolycoris baccarum, L.

This bug sucks the young sunflower seeds. The nymphs and adults are to be found on sunflowers during nearly the whole summer, and there are generally two or three nymphs on every head. The insects hibernate in the adult stage.

When the bug appears in noticeable numbers, growers sometimes shake the flower-heads over a pail containing a little water and kerosene ; but this is not very effective, as the adults often fly off and the nymphs cling very closely to the flowers.

Sunflower Aphids.

Two kinds of Aphids are found on sunflowers in Ukraine, and according to A. V. Znamensky, they are both undescribed species. The more common species is of a brownish green colour, being very similar to *Aphis rhamni*. It sucks at the edges of the flower, under the outer squamae, and is often found in large numbers up to late autumn. The other species is bright yellow, and feeds on the yellow outer petals of the flower. The life-histories of these insects have not yet been studied.

Tryonymus perrisi, Fern.*

White colonies of this Coccid were many times found on the roots of sunflower in the steppe regions of Ukraine.

* Mr. Alexis N. Kirichenko, of Odessa, was kind enough to identify them.

NOTES ON A TSETSE BELT IN WESTERN UGANDA.

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(Plate XVII and XVIII, and Map.)

Introduction.

It is felt that it may prove of interest to record briefly the history of a certain tsetse area in South Ankole, Western Province, Uganda, between the years 1906 and 1927.

I would record initially my deep appreciation of the constant assistance and advice of the Chief Veterinary Officer, Mr. W. F. Poulton, without which this work and report could not have been completed.

The belt of tsetse here discussed is looked upon as a *Glossina morsitans* belt, for although many specimens have been taken, yet close examination shows the presence of only a single *G. pallidipes*, this fly having been captured in the Kakitumba section.

No effort has been made to draw definite conclusions in this report, which is an attempt merely to record observations and work done.

It is realised that the results are not startling, and that the method of " smoke " control must continue for a further year before a definite pronouncement of its efficiency can be made.

The temptation to carry out such minor experiments in regard to the comparative effects of " smoke " on *morsitans* and other flies, and the use of various grasses and shrubs for fumigation was resisted as being likely to retard the main objectives of the work, *i.e.*, the prevention of the spread of *morsitans* and the eventual reclamation of south N'garama and Bukanga.

Natives were not used to catch flies, as their degree of industry is usually so variable that uncertainty of results appears inevitable. The method of catching flies personally was practicable because the area with which I was dealing is comparatively small.

I am sensible of the shortcomings of this report, but the investigation and compilation of results had to be carried out in conjunction with the normal duties of a Veterinary Officer, which rendered it difficult to make adequate arrangements.

In South Ankole burning is carried out during May–June and December–January.

Early History of the Fly Area.

Numerous cattle, owned by the pastoral Bahima, were grazed and watered in South Ankole prior to 1900, and conditions appear to have then been less unfavourable to cultivation, which was undertaken on a small scale and confined mainly to the gorges. Cattle appear to have been maintained in health in 1906–07 in the N'garama section, which would seem to indicate freedom from infected *Glossina*, if indeed any flies existed.

It was not until 1909 that cattle began to die from a disease previously unknown to the natives, and in 1910 the late Mr. Hutchins, Chief Veterinary Officer, Uganda, demonstrated trypanosomiasis infection, apparently due to *Trypanosoma congolense*. No tsetse were seen by him or by Dr. C. H. Marshall, who was touring South Ankole in relation to the Boundary Commission of 1909–10. Goats and sheep were also reported to be dying in numbers, the cause of death being ascribed, however, to a mange.

A movement of cattle from the south, mainly in a northerly direction, began about 1908–09 and continued in 1910, in the latter part of which year heavy losses occurred, 75–80 per cent. mortality being recorded. No deaths amongst game were noted by either European or native observers.

It is significant that this movement northwards originated from near the Kagera River, and it appears reasonable to assume that the herdsmen are correct when they state that the tsetse crossed that river, bringing with them a " new " plague which first had become apparent in " German " East Africa.

During the dry season a favourite watering place for cattle was at the mouth of the Kafunzu River (Tanganyika), and it is probable that these herds on returning northwards carried trypanosomiasis with them and also *G. morsitans* in small numbers.

Further investigations on this " new " disease were carried out in South Ankole by Kennedy, now Director of the Veterinary Department, Sudan, who in 1911 corroborated the presence of trypanosomiasis. At that time there appear to have been only 1,000 head alive in two counties that had certainly carried previously not less than 10,000 cattle. No tsetse were noted by him, and it was not until 1913 that Hutchins took them in numbers at Burumba, to the east of the Ebitatenge Valley, the species being *G. morsitans*. Further extensions followed, and this fly was taken by Dr. R. E. McConnell in the area immediately south of Lake Nakivali early in 1914.

It would seem that this sector was regarded commonly as that which resulted in the devastation of South Ankole, but it is more probable that the stock exodus caused a spread of fly to the north, creating a secondary focus (as described by Lloyd) in the Nakivali area and, probably, at the southern extremity of Lake Kachira.

Military Headquarters were situated at Simba during 1915, and there occurred considerable movement, mainly pedestrian, along the N'garama-Simba road. An easterly extension of *Glossina morsitans*, apparently confined initially to the road, was recorded, the density gradually decreasing eastwards. It was impossible to investigate closely the presence of tsetse in the country adjoining the road, but none was observed whilst hunting, although eland, oribi, impalla, wart-hog and zebra were common. Poulton states his strong belief that the spread of fly was mainly or entirely due to human agency.

Military Headquarters were then moved to Mbarara during 1915, and there was a subsequent heavy traffic on the Mbarara-Kagera road, consisting mainly of pedestrians and motor and ordinary cycles. This road linked up the uninfested northern pastures with what then appeared to be the primary centre near the Kagera River.

An immediate result of this traffic was a rapid and marked increase in the range and density of the fly, which became apparent first in the south and spread northwards, the greatest degree of concentration appearing to be on the road.

Major Hutchins decided that strong efforts must be made to check this undesirable spread northwards, for it appeared certain that, unless restrictive measures could be devised, infestation of the rich cattle areas of Western Ankole would result. The foot of Kamuli Hill was selected and operations begun there, because in this section the road followed a valley between two hills, respectively 5,000 and 5,300 feet in height. Refugees were encouraged to cultivate in this valley, and on the road was erected a grass house, in which was a small forge in charge of a guard. All traffic, whether pedestrian or wheeled, had to enter this house when leaving the fly-belt and was there subjected to smoke clouds generated by the forge fire acting on damp foliage. Many hundreds of *G. morsitans* would be present on a motor cyclist, but a short period of fumigation caused all flies to disappear, and the individual continued his journey entirely free from them.

The measures taken achieved only partial success, because (*a*) the natives, influenced by suspicion of such novel measures, avoided the house whenever possible, and their use of bush by-paths maintained a chain of fly; (*b*) the house had not been placed at the northern fringe of the belt; and (*c*) refugees were insufficient in numbers to ensure adequate cultivation.

Military operations ceased in Ankole in 1916, but the tsetse, having apparently received a marked impetus, continued its spread northwards on a broad front, the greatest density apparently being still on the Mbarara-Kagera road.

According to Poulton the picture conveyed by the observations over this period was that *G. morsitans* had been spread mainly by human agency and, further, that the fly appeared accustomed to, and showed a preference for, human diet, seeming to associate the disseminating agent with food supply.

Even in areas where the tsetse existed in such numbers that progression, whether on foot or by motor cycle, was a painful experience, the game did not appear unduly worried. Similarly, in 1916 in the Shinyanga-Mwanza area an observer was pestered by *Glossina* at a time when a herd of impalla in close proximity grazed quietly without any apparent discomfort. I have been unable, however, to trace general observations on the behaviour of game in the presence of large numbers of hungry *morsitans*. On one occasion a small herd of waterbuck in the Ntundu valley seemed unperturbed by the attention of the fly, although concentration was high; whilst on another occasion in similar circumstances a herd of zebra was grazing quietly and apparently unworried by *morsitans*. This does not conform to the observation of Swynnerton (1922) in the case of a zebra or to his statement in 1918 that buck, especially hartebeest, are very restless under the attentions of tsetse, which is corroborated by Neave. It appears strange that when man, cattle and dogs all suffer disturbance through attention from *G. morsitans*, game should escape serious inconvenience in similar circumstances.

Grass fires did not appear to affect the numbers of *G. morsitans* encountered on the infested Kagera road, for at a time when the surrounding country had been recently and thoroughly burnt, the severity of the continual fly attacks appeared unaltered; and this supported the impression that the road was the main area of infestation. Moreover, it would seem from subsequent observation in the Roborogoto-Kikigati section that, had *morsitans* been numerous in the surrounding country, the burning of the grass with the consequent exodus of the game would have resulted in a large increase of numbers on the road.

Military activity ceased in Ankole in 1916, after which date there was a marked diminution of traffic on the Mbarara-Kagera road.

It will thus be seen that in the period 1907–1917 *G. morsitans* extended its range so as to occupy the wide area indicated on the map, having advanced approximately 25 miles in four years.

Conditions between 1919 and 1927.

Rinderpest entered Eastern Ankole in 1919, sweeping through the whole of that area as a disastrous epizootic. Heavy losses were recorded amongst cattle, and among the game, eland, buffalo and wart-hog were markedly depleted in numbers.

In 1920 a lessening of *Glossina* density was evident in the area previously infested, although in that year *G. morsitans* was recorded by Veterinary Officer Hart within 12 miles of Mbarara.

It became clear in 1921 that a distinct recessionary movement was actually in progress, despite the fact that "bush" was not lessened and that certain game, such as hartebeest and waterbuck, were not scarce.

A further shrinkage of the tsetse belt occurred in 1922, and at that time there also appeared a diminution in all game, which was ascribed to concentration on the remaining species by carnivora and native hunters. The bush appeared to be increasing, and there was no particular climatic condition which could be considered as an adverse factor.

A survey made in 1923 yielded information that *G. morsitans* was becoming increasingly scarce, whilst in 1924 a further reduction of numbers was noticed and a general shrinkage of the area occupied by the fly.

The departmental report for 1925 recorded that flies were apparently non-existent in areas heavily infested in 1915. Such statements were regarded with caution, but departmental hopes were held that the tsetse would return eventually to that point on the Kagera from which, it was believed, it had originally extended.

Observations were being maintained and plans formulated to utilise clearing methods to eliminate the tsetse should it finally become restricted to an area the limited size of which would render practicable the reclamation and subsequent restocking of that country. Little work on this problem could be maintained in 1924, but in 1925 a survey was made, utilising cattle as bait, and *G. morsitans* was recorded in the Kakitumba section, to which reference is made later. Unfortunately the work lacked completeness in that the journey was not continued along the northern bank of the Kagera River in an easterly direction, but the information gained showed that a large section of previously infested country was definitely free from fly.

In 1926 a detailed programme of investigation was prepared for the ensuing year. There arose, however, a serious complicating factor that interrupted the plans, for tin was discovered at Kikigati, a main centre of the existing "belt." Mining activity at that place entailed increasing traffic, mainly motor vehicles, on the roads Y-Y and Z-Z (see Map), and reasoning by the analogy of 1915, a rapid spread of tsetse seemed assured, probably in a westerly and certainly in a northerly direction. It was feared that a reinfestation of the country would occur to a more serious extent than previously, because not only was game recovering in numbers owing to the protection afforded it, but also the bush showed an increased density.

Careful examination of the position indicated that the proper utilisation of the tin field activity might turn an apparent menace into a distinct asset, always provided that an extension of fly could be prevented. It seemed plain that prompt action would have to be taken and reliance placed on the use of smoke-houses to prevent the transport of *Glossina* from the infested to the clean country. The partial success obtained from the procedure in 1915, when considered in conjunction with the steps taken by natives in the southern Sahara (Chapeyrou, 1922), was regarded as sufficient justification to adopt the fumigation measures.

A detailed and complete survey was made of the area to define clearly the limits of the fly, four head of cattle and three dogs being used as bait ; a motor car of dark crimson-lake colour with a black hood was also utilised as a supplementary measure and found to be especially attractive when travelling at 15–20 m.p.h. This preliminary survey occupied from 30th March to 13th April, and by 20th April one smoke-house was erected near Roborogoto, at the limit of the fly section, to guard the western road, Y-Y, which was at that time the main traffic route. The design of the house allowed the fumigation of three-ton loaded lorries (Pl. xviii), the smoking arrangements being temporarily carried out by means of native bellows and green leaves or grass.

The northern road, Z-Z, from Kikigati to Mbarara, was in process of construction, and on its completion in May an inspection was made to demarcate the limits of *G. morsitans* in that sector. This fly was found along both sides of the new road for a distance of eight miles, and it was resolved to undertake the intensive clearing

of a strip of country extending across a valley at a point where the surrounding hills, 5,000 feet in height, converge slightly, and through which the road passes. This cleared strip, 1½ miles across and ¾ mile broad, was extended up the wooded slopes of the hills to the open land on their crests. A smoke-house was also erected in the centre of the clearing and astride the road to ensure adequate control of passing traffic. These measures were completed by August.

Having thus done what was possible in so short a time to meet the sudden danger of mining activity causing a spread of *Glossina*, investigations in the fly-belt were resumed, in the hope that continued intensive observations would enable steps to be taken to utilise the tin mines to the greatest advantage in anti-tsetse measures. Permission was obtained for the free-cutting of brushwood by the tin-field workers on the condition that such cutting should be undertaken at specified points. It is anticipated that large quantities of firewood will be required for the boilers of the water-pumping plant, and that if this is cut under directed control, dangerous areas can thus be cleared and the reclamation of southern Ankole facilitated.

The following points were specially considered: (*a*) fly density in various parts of the belt; (*b*) the possible presence of *Glossina* other than *morsitans*; (*c*) position of main breeding-places; and (*d*) influence of game and location of water-holes frequently visited by game.

It is proposed to deal in detail with the area under eight separate sections.

The Kakitumba Section.

This section is a comparatively small isolated focus of *G. morsitans* situated at the junction of the Kakitumba, Kagera and Kabobo Rivers and it is in this belt that one specimen of *G. pallidipes* has been taken.

Reference to the map will show that the Kakitumba and Kabobo Rivers flow into the Kagera River near its emergence from the Tanganyika hills. As the banks of these rivers are lined with bush, extending in the case of the Kafunzu, a tributary of the Kakitumba, up to the Roborogoto-Mbarara road, and as *G. morsitans* was known to be present near the Kakitumba-Kagera junction, it was resolved not only to determine the area infested but also to gauge the possibility of a future northerly extension to the main road.

The area was thoroughly traversed, five different routes being followed. Bush, comprised mainly of flat-topped acacia and thorn, is encountered in close proximity to the western bank of the Kafunzu River, extending from the road to the Kakitumba and for about six miles along the southern base of Kateramma Hill. The Kakitumba River flows through a deep gorge, the sides of which are covered with thick undergrowth and lined with trees approximately 70 feet in height.

Similar acacia and thorn bush covers the low-lying country enclosed by the Kafunzu, Kakitumba and Kabobo Rivers and the Meramma-Kampanga range of hills. The whole of this area would seem eminently suitable to the needs of *G. morsitans*, and the banks of the Kakitumba suitable to those of *G. palpalis*. This latter fly, however, was not encountered.

The valley of the Kasanda (Kafunzu) to the north of the road is also covered with the same type of bush, and appears as suitable for *G. morsitans* as does their habitat further south.

The following species of game were seen in this area: eland (about 20), roan (about 40), waterbuck (about 40), zebra (numerous), reedbuck (numerous), topi (numerous), wart-hog (fairly common), oribi (fairly common), duiker (fairly common), and buffalo (tracks seen at river).

There are no cattle in this section, but there are two small herds four miles north of the fly focus and near the Roborogoto road. They have been present in that area

since 1921 and appear to have been healthy until recently. These herds occasionally graze in the plain south of the road, but normally when feeding do not reach the fly-area, as their watering place is on the north side of the road. They have, however, owing to severe drought, recently been forced to water at the Kabobo River, with the result that deaths are now occurring from trypanosomiasis.

Investigations of the belt were generally carried out on hot sunny days, but rain occurred not infrequently in the late afternoon or during the night. *G. morsitans* was found over an area stretching from the southern end of Meramma Hill, eastwards along the Kagera, and across the Kabobo, to a point on the banks of the main river 1½ miles from the Kabobo-Kagera junction, as shown on the map. The concentration was low, the average catch being four per hour, the percentage of females taken being 20.

There appears to be no satisfactory reason for the restriction of the fly to such a small area when the adjoining country (frequented by many species of game) is both suitable and accessible to them. The limitation of this focus may be due to the strong instinct against wandering quoted by Jack (1920). The low fly concentration encourages the belief that at present there is little danger of the belt extending northwards to threaten the main road.

Owing to the rapid current and depth of the Kakitumba it proved impracticable to cross to Tanganyika, but information obtained from the natives of that territory indicated the presence there of *G. morsitans*.

This Kakitumba focus is not of major importance, as there are neither natives nor cattle resident in it and little traffic passes through it. The present steady growth of the Ankole cattle population will, however, demand the eventual reopening of this area. One might suppose that it constitutes an isolated outpost of a main belt and depends for its existence on replenishment from the fly-area, if such exists, in the neighbouring territory.

The Kabiganda Valley.

This valley lies between the Ruzinga and Nishesh Hills and runs northwards for a distance of about nine miles. It is hemmed in to the north, east, and west by hills averaging 5,000 feet in height and is bottle-shaped, the "neck" communicating with the Ntundu Valley.

This area has been under close observation since July 1927. The river shown on the map is generally a dried-up watercourse, containing long grass, thickets of trees and undergrowth, but water-holes, sometimes connected by small streams, are present in the long rainy season. There is one permanent water-hole at the southern and another at the northern end of the valley, where there are also a few buffalo wallows. A rough road has been constructed for a distance of about six miles along the valley by tin prospectors. The whole of this area from the entrance to the northern end is covered with thick bush of the usual thorn and acacia type.

The following game animals occur: elephant (present during the rains), buffalo (roam through the valley but appear to prefer the northern end), roan (few), oribi (few), waterbuck (few), pig (few), reedbuck (fairly numerous), monkeys (fairly numerous), baboons (common), and zebra (tracks seen).

Investigations were made to ascertain the concentration of *Glossina* in different sections of this valley, with the following results. *G. morsitans* is commonest in the "neck" between points opposite Ruzinga and Chamtwara Hills. The average catch on the prospectors' road was ten per hour. These flies were taken on the inside of the black hood of a car, the maximum catch being obtained by running the car at 15–20 m.p.h., a stop being made every 400–500 yards to secure such flies as were

congregated under the hood. Collecting on foot on the same road over a similar distance was less successful, the average falling to four per hour. From opposite Chamtwara Hill northwards along the road only occasional flies are seen.

The southern game water-hole was visited at different hours and under varying climatic conditions, but, contrary to expectations, no tsetse were seen or secured inside the area mapped off by the tall trees surrounding it, even though four natives were employed to disturb foliage. Prolonged and continuous search for pupae or pupa-cases yielded negative results.

The most northern point at which *morsitans* was captured was at the junction of the Mistimba and Kabiganda Rivers, seven being taken there in a few minutes, within a short distance of a gang of road labourers, who were not, however, suffering from attacks by the fly. These men had recently walked to the spot, passing *en route* through the more heavily infested centre, and it was considered they had been accompanied by flies on their journey northwards. With this exception, concentration of tsetse had been steadily diminishing and they appeared entirely absent beyond this point.

The northern wallows and water-holes at the head of the valley were searched thoroughly, but although they appeared to be in daily use by large numbers of game only five roan and one reedbuck were seen. Attempts to "flush" animals in order to permit examination of resting places were unsuccessful. No tsetse were observed.

It appears worthy of record that three *morsitans* were seen on the comparatively bare top of Buvari Hill (4,500 ft.), where a reedbuck had been disturbed.

The Kabiganda Valley is suitable for *G. morsitans*, both cover and food being plentiful, yet the concentration appears to be low ; although on occasions there was marked temporary increase, coincident with the passage through the valley of a herd of buffalo. For example, a native assistant, who was in charge of dogs retained in the belt to test the presence of *T. brucei*, stated that in July 1927 *morsitans* were very numerous in the immediate vicinity of the water-hole at the southern end of the valley, during the time that a herd of buffalo was lying up in the surrounding thickets. These animals returned to their usual habitat at the head of the valley two weeks later ; careful personal search 14 days afterwards failed to reveal any tsetse.

There are no natives resident in the Kabiganda Valley, with the exception of a few porters working with a mining prospector, and no cattle graze there.

The Ntundu Valley.

Reference to the map will show this valley running north-west from the Kagera River behind Ntundu Hill, rounding the base of Buvari Hill to merge into the southern end of the Kabiganda Valley at Ruzinga Hill. It is bounded to the north by a line of hills averaging 4,600 ft. in height and to the south by Ntundu Hill, 4,575 ft., but to the east and west it is less clearly defined.

This valley is thickly covered over the whole of its extent by thorn and acacia trees. There are no cattle or people and no road passes through it. Along the base of the valley run numerous game tracks leading to the Kagera River, and to a small salt-lick situated near the eastern end. The following game was seen : roan (few), waterbuck (few), zebra (fairly numerous), reedbuck (fairly numerous), and oribi (few). The fresh tracks of a large herd of buffalo were observed near the salt-lick.

An average catch of 25 flies per hour was recorded at the western end, the concentration increasing further in the valley to 56 per hour, which high average was maintained to within one mile of the Kagera River, where it dropped rapidly to 20 per hour. The flies, although numerous, were not troublesome on hot sunny days, but on afternoons and evenings following the heavy showers that herald the onset of the rainy season, they attacked viciously both stationary and moving persons. On one occasion they persistently attempted to feed after sunset and until darkness had fallen.

The Roborogoto-Kikigati Road.

These notes deal with the Kikigati-Roborogoto section of the western main motor transport route to Mbarara (marked Y–Y on the map), the distance between the two former places being eleven and a half miles. From a point about one and a half miles from Roborogoto, to a point half a mile from Kikigati, the road is lined on both sides by thick bush, which varies in depth from one to two miles on the south side and diminishes in density towards the Kagera River plains. On the north side the bush is hemmed in by hills between 4,500 ft. and 5,000 ft. in height.

There are no special features of interest as regards the topography of the road, with the exception of the fact that where it is crossed by the Kivimbiri River there is a fairly extensive dry watercourse, with occasional thickets and tall trees. The following game animals were seen : eland (a few small herds), zebra (numerous), roan (few), waterbuck (common), topi (common), reedbuck (common), oribi (scarce), duiker (few), pig (very common), and buffalo (tracks of two seen in a dry watercourse).

The fly-belt begins about one mile east of the Roborogoto smoke-house and ends at the Kikigati clearing. The concentration varies at different parts and at different times of the year. It is lowest at the Roborogoto end, increasing as the western end of the Ntundu Valley is approached, and then gradually diminishing as Kikigati is reached. During the month of April, while the grass on either side of the road was long, *morsitans* was plentiful, an average catch of 25 being made from the hood of the car during the journey of 11½ miles between Roborogoto to Kikigati. The flies at that time did not feed readily on passengers in the car.

There was a marked change of habit in May, after grass burning had ceased. Game was scarce, if not entirely absent, from the vicinity, and the fly became most vicious, showing however a preferential desire for natives rather than for Europeans.

The grazing in the area was negligible during July and August, when the game remained in the bush-free plains to the south, and at this time the fly, as if forced by continued hunger to relinquish preferential diet, attacked natives and Europeans with impartial and persistent voracity.

Game returned to the improved grazing in the bush and fly-area during September, when there was an immediate and most marked fall in the numerical density of *Glossina*, and no desire for a human diet was manifested. The catch would increase suddenly on occasions, but this usually, although not always, coincided with signs of game having recently crossed the road.

The Plain Country.

These are extensive rolling plains of short grass running from the fly belt on the road Y–Y down to the Kagera River. They are almost treeless and are generally uninhabited by either natives or cattle, and wild fauna is common. The following species have been seen on many occasions : zebra (in large numbers), eland (40 to 50), roan (about 40), topi (numerous herds), waterbuck (numerous herds), reedbuck (very numerous), oribi (fairly numerous), pig and warthog (numerous).

No tsetse are present on these plains.

The Kikigati-Nyaruambu Section.

This applies to the strip of bush between the Kagera River and the hills to the north, through which runs the new road from Kikigati to the junction of the Ebitatenge and Kagera Rivers and then northwards to join the Mbarara-Gayaza road. The greatest breadth is approximately one mile.

Game is scarce, except for the crossing of the road towards the river by an occasional animal. Tracks of a buffalo herd were seen on the road only on one day.

Flies are scarce throughout the year over the whole of this section, and the average catch in the bush was less than five per hour, whilst on the road it was slightly

higher. A record catch of 18 was made on the road after the buffalo mentioned above had passed over it; the percentage of females recorded in that batch was 28. The flies taken appeared from their engorged condition to have been feeding on the buffalo.

The Ebitatenge Valley.

This valley runs north from the Kagera River and through it passes the new road from Nyaruambu to join the Mbarara-Gayaza road near the southern end of Lake Nakivali. The distance from the Kagera River to the Gayaza road is approximately 15 miles. The valley is mainly covered with thick bush of the usual thorn and acacia type. It is uninhabited, except for a few native owners of banana plantations situated to the west of the road, about seven miles from the Kagera.

Baboons and pig are commonly observed in this area during the day, but spoor is seen of waterbuck, topi, reedbuck, zebra and lion, which apparently cross the valley to the water-holes and swamps during the night or early in the morning.

The history of the area has already been dealt with on page 422. Hutchins remarked in 1913 that *G. morsitans* were very numerous along the banks of the Kagera at a point named Burumba. From this date onwards it would seem that the fly belt gradually spread northwards up the valley of the Ebitatenge, as far as the Lake Nakivali area, and then spreading along the Mbarara road until, by 1917, it had approached to within less than 20 miles of Mbarara.

The rapidity of retrogression is illustrated by the fact that during May 1927 the most northern point of the fly belt was only eight miles from the river. This was before the onset of the dry weather and the consequent mid-year grass burning. On passing along the road in a car 16 *morsitans* were collected inside the hood in half an hour.

During the month of August, after the grass had been thoroughly burnt, it was found that the flies had receded to within 600 yards of the river bank, a variation of approximately $7\frac{1}{4}$ miles being thus recorded in different seasons. Visits at various other times during the dry season confirmed this marked withdrawal.

The rains began in October, general cover improved, and the tsetse commenced local migration northwards, stray *morsitans* being captured in that month at a distance of five miles from the Kagera. This expansion continued and in November again attained the maximum range of eight miles, in similar conditions to those obtaining six months previously.

The Kagera Valley East of Nyaruambu.

The bank of the Kagera east of Nyaruambu was examined for the first time, during November, for a distance of about five miles, which embraces the centre at which Hutchins took *morsitans* in 1913. This species was observed over the whole area inspected, the catch averaging 11 per hour. Owing to pressure of other work it was not possible at that time to proceed further in this easterly direction.

Detailed Preventive Measures against Spread of G. morsitans.

The western exit was not so serious a question as the northern, for the past history indicated that there was no marked tendency to spread in this direction. The site for the smoke-house was selected on the edge of the bush flanked on the one side by open plain and on the other by hills averaging 4,500–5,000 ft. in height. Natural spread was unlikely to occur, the main danger being the introduction by motor transport of large numbers of *morsitans* into the thickly wooded areas around Chitwa, west of the Kabobo River, a distance of $7\frac{1}{2}$ miles. In the event of this happening the fly might then link up with the Kakitumba centre, and a further serious situation would result.

At the northern exit, in the Ebitatenge Valley, the fly had shown a marked tendency to spread northwards in the past, and it was anticipated that rapid extensions would occur. The road runs through a wooded valley approximately $2\frac{1}{2}$ miles wide bounded by bare-topped hills averaging 5,000 ft. in height, and it appeared comparatively useless to place a smoke-house in the centre of such country. Natives could pass around the house by bush paths, whilst game trekking north from the river might also act as disseminating agents.

Although big game was comparatively scarce, motor cars were not, and an endeavour was made to meet all the factors by the combination of a clearing and a smoke-house, which latter was erected in the centre of the former.

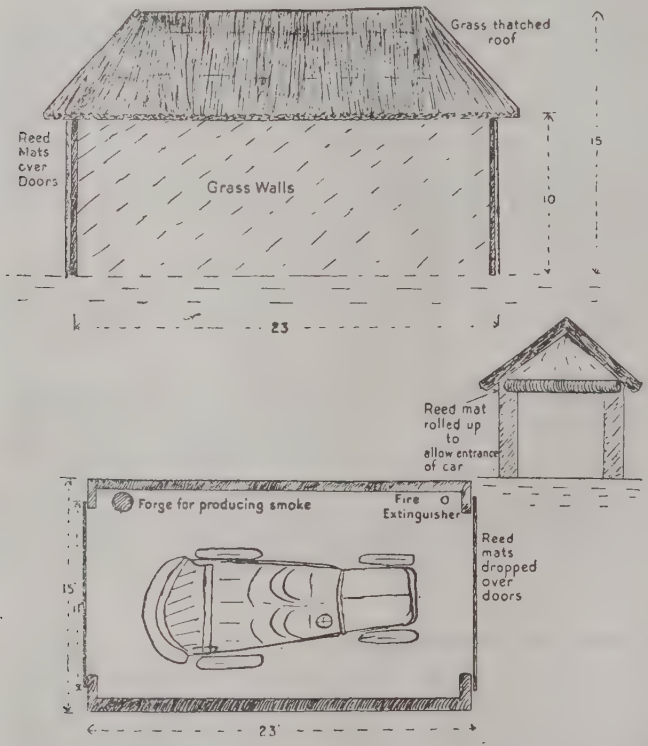


Fig. 1. Type of smoke-house erected on roads from the Kagera River fly-belt.

It was also feared that fly, leaving cars immediately prior to arrival at the smoke-house, would enter the bush and accidentally rejoin the car after it had been "smoked." This would cause complete failure of the fumigation procedure and maintain a chain of fly, as happened in 1915. A spot was therefore selected four miles from the furthest extension of the fly-belt at a point where the valley narrowed to $1\frac{1}{2}$ miles in width.

After collaboration with the Provincial Administration, the Native Government provided labour to clear completely across the valley and to a depth $\frac{3}{4}$ of a mile.

The plan on which the smoke-houses were constructed is shown in the accompanying sketches (fig. 1). The material used was grass and poles, of the varieties

commonly utilised by natives in building their houses. When first erected there were fitted heavy thatched doors at both ends of the buildings, but these were later replaced by light mats. A looped rope suspended from above is passed round the mats so that they can be rapidly raised or lowered. Initially, native bellows were used to generate smoke, but these were soon replaced by portable blacksmith's forges, one to each house; the spark confiner was, however, increased to complete the circumference of the forge.

A car is driven into the house and the mats at both ends lowered; damp foliage is then placed on the embers of the forge and draught gently induced, a considerable volume of smoke being thus produced in a short time.

The car and occupants continue the journey after five to seven minutes' fumigation, during which time no serious discomfort is experienced. On no occasion have any flies been observed on cars or passengers after emergence from the smoke-house, although undoubtedly present at the time of entry.

An Experiment with Dogs in a Fly-area.

Three dogs were introduced into the fly-belt, where they were subjected daily to exposure to *Glossina morsitans* under natural conditions, in the hope of obtaining *Trypanosoma brucei* infections.

One dog died suddenly, but unfortunately the blood smears sent in by the native in charge were taken badly, and, although trypanosomes could be seen on microscopical examination, it was impossible to identify them.

The remaining two dogs gave negative results after four months' residence among *morsitans*. It was observed that as the animals lost condition the flies refused to feed on them, and I received a request from the native in charge to be supplied with a net to catch flies and "hold them on to the dog." This experience coincides with that of Newstead and Davey (1914) in relation to anaemic fowls and refusal to feed by tsetse.

Examination of the Blood of Game.

Dry blood and gland smears from various species of game were microscopically examined for trypanosomes, with the following results:—

Species.	*Area.*	*Source.*	*Result.*
Zebra	Ntundu Valley	Blood	*T. congolense*
Zebra	Ntundu Valley	Gland	Negative
Waterbuck ...	Ntundu Valley	Blood	*T. brucei*
Waterbuck ...	Kikigati–Roborogoto Road	Gland	Negative
Reedbuck ...	Kagera Plains	Blood	*T. brucei*
Reedbuck ...	Kagera Plains	Gland	Negative
Eland	Kagera Plains	Blood	Negative
Eland	Kagera Plains	Gland	Negative
Reedbuck ...	Kabiganda Valley	Gland	Negative
Reedbuck ...	Kakitumba River	Gland	Negative
Waterbuck ...	Kagera Plains	Gland	Negative
Waterbuck ...	Kagera Plains	Blood	Negative
Oribi	Kagera Plains	Blood	Negative
Dog	Kikigati–Roborogoto Road	Blood	Negative
Waterbuck ...	Kikigati–Nyaruambu Section	Gland	Negative
Waterbuck ...	Kikigati–Nyaruambu Section	Blood	Negative
Reedbuck ...	Kagera Plains on edge of bush	Blood	Negative
Dog	Kikigati	Blood	*T. brucei*
Cattle	Chiragussu–Kagera Plains	Blood	*T. brucei*
Dog	Kikigati–Ntundu–Kabiganda Sections	Blood	Negative

Numerous slides of the cattle and dogs used as bait were examined, as were the subjects " subinoculated," but they have not been included as all were negative.

Summary.

Prior to 1900–05 South Ankole was free from tsetse.

About 1906–07 *Glossina morsitans* crossed the Kagera northwards at three points : Kakitumba, Nyaruambu, and Kafunza (Tanganyika). Cattle in those areas were moved north on the advent of the fly, thus spreading it in small numbers, mainly northwards.

The epizootic recorded in Ngarama and Bukanga in 1910–11 was due to " direct " transmission following the introduction of infected cattle from the south.

The influx of man in 1914–15 through the Nyaruambu and Kafunza centres, chiefly the former, caused marked disturbances and rapid spread of the fly, principally along the line of communication to the north.

The sudden withdrawal of the human element resulted in marked diminution of fly density, and the advent of rinderpest in 1919 destroyed an important alternative food supply, thus giving further impetus to the reduction.

After a period of 27 years the tsetse had retired to those two points from which it had originally spread.

The Kakitumba centre had not suffered human invasion, as did the foregoing, and no great activity of *Glossina* has therefore been recorded.

The picture presented is that man himself has proved the greatest factor in that wide and rapid spread of *Glossina* which Ankole experienced during 1907–1917.

The impressions formed from detailed work are :—

(1) The Ntundu Valley is now the primary centre, and serves as a feeder to the Kabiganda and Nyaruambu fly-areas.

(2) The fly depends on game for its existence.

(3) Transportation by man and his vehicles constitutes a grave factor in the spread of the tsetse.

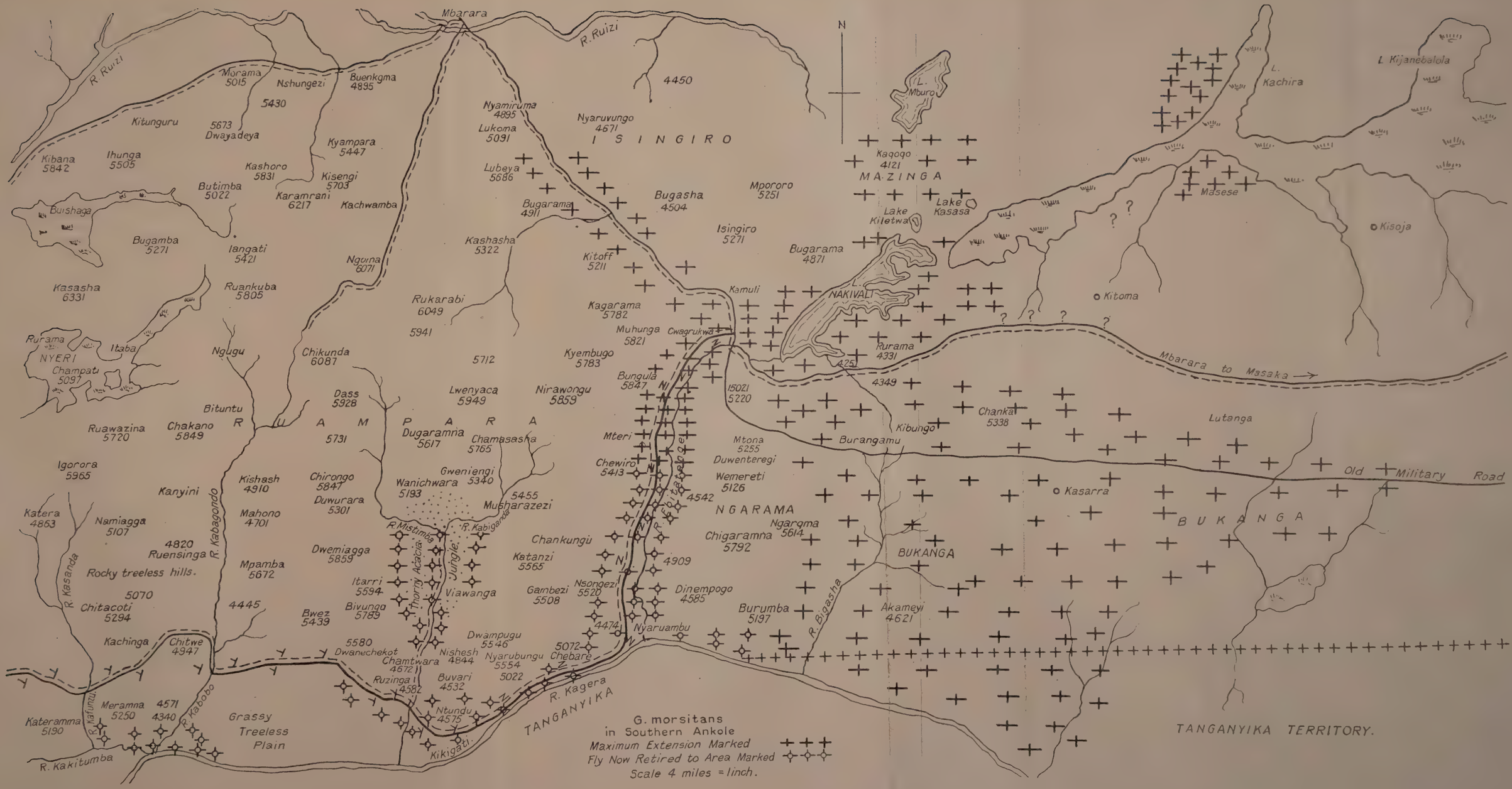
(4) Smoke-houses, supported in certain circumstances by clearings, should prove valuable factors in control.

(5) A motor car is a most useful adjunct in the making of tsetse surveys.

Postscript.

[Some months after the foregoing paper was written, Mr. Simmons wrote to say that there had been an unexpected change in the tsetse position in the area referred to. At the time when the paper was completed it was considered that *G. morsitans* had evacuated the country infested by it during the War, and had retired to within a few miles of the Kagera River. This conclusion was based on the fact that a competent observer, with bait cattle, had failed to find fly either on the road that was heavily infested in 1916–17 or in the bush to the east and west of the road. Further, the country had been frequently hunted over since the War without any *G. morsitans* having been observed.

Three months ago, however, a shooting party encountered a few *morsitans* in a small patch of short green grass near the base of Kamuli Hill (on the Mbarara road, west of Lake Nakivali). On this being reported to him, Mr. Simmons immediately made a thorough search of the surrounding country, the whole of which is covered with fairly thick acacia bush, and discovered *morsitans* in the Lugeye Valley, which runs westwards from Lake Nakivali across the Mbarara road south of Bugarama. Flies were more or less continuous along the banks of the dried-up watercourse of


Mbarara
R. Ruizi
Morama 5015
Nshungezi
Buenkgma 4895
5430
Kitunguru
5673 Dwayadeya
Kyampara 5447
Kibana 5842
Ihunga 5505
Kashoro 5831
Kisengi 5703
Butimba 5022
Karamrani 6217
Kachwamba
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Bugamba 5271
Iangati 5421
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NYERI
Champati 5097
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Ruawazina 5720
Chakano 5849
Dass 5928
5731
Dugaramna 5617
Chamasaska 5765
Igorora 5965
Kishash 4910
Chirongo 5847
Kanyini
Duwurara 5301
Katera 4863
Namiagga 5107
Mahono 4701
4820 Ruensinga
Rocky treeless hills.
Mpamba 5672
5070 Chitacoti 5294
4445
Bwez 5439
Kachinga
Chitwe 4947
5580 Dwanechekot
Meramna 4571
5250
4340
Kateramma 5190
R. Kakitumba
R. Kafuntu
R. Kabobo
Grassy Treeless Plain
R. Kasanda
R. Kabagondo
Gwenlengi 5340
Wanichwara 5193
5455 Musharazezi
R. Mistimba
R. Kabigarama
Thorny Acacia Jungle
Viawanga
Chankungu
Katanzi 5565
Gambezi 5508
Nsongezi 5520
Dinempogo 4585
Nyaruambu
Dwampugu 5546
Nishesh 4844
Nyarubungu 5554
5022
Chamtwara 4672
Ruzinga I 4582
Buvari 4532
Ntundu 4575
Kikigati
Chebare 5072
R. Kagera
TANGANYIKA
4450
Nyamiruma 4895
Lukoma 5091
Nyaruvungo 4671
I S I N G I R O
Lubeya 5686
Bugarama 4911
Kashasha 5322
Kitoff 5211
Rukarabi 6049
5941
5712
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4349
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Duwenteregi
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NGARAMA
Ngarama 5614
Chigaramna 5792
Burumba 5197
Akameyi 4621
R. Bigasha
BUKANGA
Kaqogo 4121
MAZINGA
L. Mburo
Lake Kiletwa
Lake Kasasa
Rurama 4331
425
Kibungo
Burangamu
Chankai 5338
Lutanga
Old Military Road
Kasarra
BUKANGA
L. Kachira
L. Kijanebalola
Masese
Kisoja
Kitoma
Mbarara to Masaka
N
G. morsitans in Southern Ankole
Maximum Extension Marked
Fly Now Retired to Area Marked
Scale 4 miles = 1 inch.
TANGANYIKA TERRITORY.

the Lugeye, the average catch being about 4 or 5 an hour, with an occasional female. The area was again visited two months later, in September 1928, when the flies seemed to be more numerous and more widely distributed; but this was probably due mainly to some light rains, which had improved the grazing and led to the return of the game.

It is not possible yet to say from which primary focus these flies have come. They may have found their way by some path through the hills to the south from the Kabiganda Valley focus. But Mr. Simmons rather favours the view that they may have come from a hitherto unsuspected focus on the shores of Lake Nakivali, which is an out-of-the-way and seldom visited lake. This can only be settled by observations which will be made next dry season.

Mr. Simmons reports that the clearing and smoke-house in the Ebitatenge Valley, referred to in his paper, were still satisfactorily holding the fly in check three months later, although it was plentiful right up to the edge of the clearing on the infested side.—Ed.]

Fig. 1. Typical *Glossina morsitans* country. The maximum catch was 56 per boy-hour.

Fig. 2. Fumigation house in process of construction in a cleared area about one mile long and three-quarters of a mile wide.

Two views of the completed fumigation house.

COLLECTIONS RECEIVED.

The following collections were received by the Imperial Bureau of Entomology between 1st October and 31st December, 1928, and the thanks of the Managing Committee are tendered to the contributors for their kind assistance :—

Mr. AFSHAR :—3 Diptera, 4 Hymenoptera, 31 Rhynchota, and 218 Orthoptera; from Persia.

Dr. T. V. RAMAKRISHNA AYYAR :—31 Parasitic Hymenoptera ; from South India.

Prof. H. A. BALLOU :—20 Jassidae ; from Trinidad.

Mr. P. J. BARRAUD :—16 Culicidae, 4 Tabanidae, 700 other Diptera, 5 Rhynchota, and 25 Orthoptera ; from India.

Mr. G. E. BODKIN, Government Entomologist :—4 Diptera, 25 Coleoptera, 2 Hymenoptera, 15 Lepidoptera, 3 Rhynchota, 6 Orthoptera, and 20 Ticks ; from Palestine.

Dr. G. BONDAR :—160 Coleoptera, 2 Hymenoptera, and 12 Rhynchota ; from Brazil.

Dr. G. BROOKE :—1 Culicid ; from Borneo.

Dr. P. A. BUXTON, London School of Tropical Medicine :—2 Tabanidae, 9 *Lyperosia*, 4 *Stomoxys*, 6 other Diptera, and 4 Coleoptera and 50 larvae ; from various localities.

CHIEF ENTOMOLOGIST, PRETORIA :—286 Coleoptera, 1 species of Coccidae, and 16 other Rhynchota ; from South Africa.

Mr. E. C. CHUBB, Durban Museum :—124 Rhynchota and 20 Orthoptera ; from Natal.

Mr. H. COMPERE :—55 Parasitic Hymenoptera ; from various localities.

Mr. G. H. CORBETT, Government Entomologist :—32 Diptera, 66 Coleoptera, 144 Parasitic Hymenoptera, 103 Lepidoptera and 2 early stages, 40 Rhynchota, 3 Orthoptera, and 3 tubes of Mites ; from the Federated Malay States.

Mr. P. R. DUPONT :—1 species of Coccidae ; from the Seychelles.

EUROPEAN PARASITE LABORATORY, HYÈRES :—14 Parasitic Hymenoptera ; from France.

Mr. T. BAINBRIGGE FLETCHER, Imperial Entomologist :—120 Parasitic Hymenoptera and 140 Orthoptera ; from India.

Mr. J. C. M. GARDNER, Systematic Entomologist :—194 Coleoptera, 119 Parasitic Hymenoptera, 9 Lepidoptera, and 57 Orthoptera ; from the United Provinces, India.

Mr. B. A. R. GATER :—16 Culicidae and 24 slides of Mites ; from the Federated Malay States.

Mr. L. GAUMONT :—33 Parasitic Hymenoptera and 24 cocoons ; from France.

Mr. J. GHESQUIÈRE :—2,000 Coleoptera ; from the Belgian Congo.

Dr. L. GILL :—158 Braconidae and a number of cocoons ; from South Africa.

Mr. P. v. d. GOOT :—10 Coleoptera and 8 Lepidoptera ; from Java.

Mr. M. GRAHAM :—45 Rhynchota ; from Lake Victoria Nyanza, East Africa.

Mr. W. GREENWOOD :—3 Diptera, 16 Lepidoptera, 34 Thysanoptera, 4 Trichoptera, and 7 Mites ; from the Fiji Islands.

Mr. W. B. GURNEY, Government Entomologist :—96 Diptera, 191 Coleoptera, 5 Parasitic Hymenoptera, 10 Lepidoptera, 55 Rhynchota, and 9 Orthoptera ; from New South Wales, Australia.

Mr. G. L. R. HANCOCK, Assistant Entomologist :—8 Culicidae, 21 other Diptera, 24 Coleoptera, 140 Parasitic Hymenoptera and 2 cocoons, 66 Lepidoptera, and a species of Aleurodidae ; from Uganda.

Mr. E. HARGREAVES, Government Entomologist :—11 Culicidae, 87 other Diptera, 111 Coleoptera, 241 Parasitic Hymenoptera, 7 other Hymenoptera, 70 Lepidoptera,

4 Thysanoptera, 15 species of Coccidae, 1 species of Psyllidae, 102 other Rhynchota, 26 Orthoptera, 7 Embiidae, 9 Planipennia, 2 Odonata, and 11 Trichoptera; from Sierra Leone.

Mr. G. F. Hill, Entomologist:—4 Coleoptera, 2 Parasitic Hymenoptera, 22 Ticks, and 8 Mites; from Victoria, Australia.

Dr. W. Horn:—35 Parasitic Hymenoptera; from Germany.

Imperial Bureau of Mycology, Kew:—1 tube of Mites; from Cyprus.

Mr. F. P. Jepson, Assistant Entomologist:—250 Isoptera; from Ceylon.

Prof. C. R. Kellogg:—2 Tabanidae, 18 other Diptera, 16 Coleoptera, 66 Parasitic Hymenoptera, 103 other Hymenoptera, 3 Lepidoptera, 15 Rhynchota, and 3 Orthoptera; from China.

Dr. W. A. Lamborn, Medical Entomologist:—77 Diptera and 71 pupal pelts; from Nyasaland.

Mr. W. A. McDougall:—45 Parasitic Hymenoptera; from North Queensland, Australia.

Dr. C. A. Marelli:—113 Orthoptera; from the Argentine Republic.

Mr. B. De Meillon:—7 Diptera and 10 pupae, 45 Coleoptera, 2 Hymenoptera, 2 Psocidae, 3 Mallophaga, 33 Anoplura, and 226 Mites; from South Africa.

Mr. J. Minnery:—16 Hymenoptera; from Tanganyika Territory.

Dr. Ahmed Mirza:—13 Coleoptera; from South India.

Dr. C. Moreira:—54 Coleoptera and 6 early stages; from Brazil.

Mr. L. Moritz:—169 Orthoptera; from Persia.

Mr. H. M. Morris, Government Entomologist:—40 Cecidomyiid early stages, 1 species of Coccidae, 1 species of Aleurodidae, and 1 tube of Mites; from Cyprus.

Nairobi Museum:—34 Tabanidae, 3 Hippoboscidae, 12 *Glossina*, 540 other Diptera, 12 Parasitic Hymenoptera, 40 other Hymenoptera, 313 Orthoptera, 55 Planipennia, 120 Odonata, 3 Spiders, 6 Scorpions, and 5 Crustacea; from Kenya Colony.

Dr. A. Ogloblin:—221 Orthoptera; from the Argentine Republic.

Dr. G. Paoli:—2 Coleoptera, 62 Parasitic Hymenoptera, and 15 Lepidoptera and 2 larvae; from the Italian Somaliland.

Mr. F. R. Parnell:—9 Braconidae; from South Africa.

Mr. W. H. Patterson, Senior Entomologist:—1 Braconid and 2 cocoons; from the Gold Coast.

Mr. A. W. J. Pomeroy, Government Entomologist:—25 Tabanidae, 12 *Glossina*, 10 other Diptera, 8 Coleoptera, 51 Lepidoptera, 2 Rhynchota, 13 Orthoptera, and 2 Trichoptera; from the Gold Coast.

Mr. R. Pussard:—923 Parasitic Hymenoptera; from France.

Mr. Y. Ramachandra Rao, Government Entomologist:—13 Coleoptera and 2 Rhynchota; from South India.

Mr. G. Samuel:—90 Thysanoptera; from South Australia.

Mr. H. W. Simmonds, Government Entomologist:—7 Parasitic Hymenoptera and 4 species of Coccidae; from the Fiji Islands and Christmas Island.

Mr. B. Sokanowski:—85 Parasitic Hymenoptera; from Russia.

South Australian Museum, Adelaide:—1,688 Coleoptera; from various localities.

Standard Telephones & Cables, Ltd., London:—15 Dermestid early stages; from the Straits Settlements.

Mr. C. F. M. Swynnerton:—2 Bombyliidae; from Tanganyilka Territory.

Mr. C. B. Symes, Medical Entomologist:—576 Culicidae, 9 Tabanidae, 5 *Glossina*, 24 *Auchmeromyia*, 3 *Cordylobia*, and 398 other Diptera; from Kenya Colony.

Mr. A. W. Taylor:—166 Culicidae, 22 Tabanidae, 9 *Glossina*, 3 *Stomoxys*, 28 other Diptera, and 28 Ticks; from Northern Nigeria.

Mr. A. Théry:—574 Orthoptera: from Morocco.

Dr. H. Thomann:—31 Parasitic Hymenoptera; from Switzerland.

Mr. H. P. Thomasset :—6 Culicidae, 32 other Diptera, 20 Coleoptera, 12 Hymenoptera, 64 Lepidoptera, 29 Rhynchota, and 2 Orthoptera ; from Natal.

Wellcome Tropical Research Laboratories, Khartoum : 9 Hippoboscidae, 16 *Lyperosia*, 12 *Stomoxys*, 117 other Diptera, 188 Coleoptera, 335 Parasitic Hymenoptera, 4 Lepidoptera, 68 Rhynchota, and 8 Orthoptera ; from the Sudan.

Mr. V. B. Wigglesworth, London School of Tropical Medicine :—45 Tabanidae, 30 *Glossina*, 122 *Lyperosia*, 83 *Stomoxys*, 2 *Auchmeromyia*, 147 other Diptera, and 9 early stages, 34 Coleoptera, 37 Hymenoptera, 15 Lepidoptera, 7 Isoptera, 14 Rhynchota, 3 Orthoptera, and 2 Odonata ; from Nigeria.

Dr. F. Zacher :—4 Coleoptera ; from Germany and North Eastern Siberia.

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